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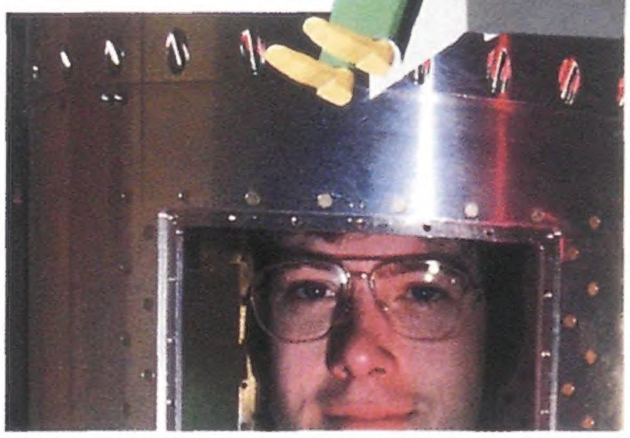

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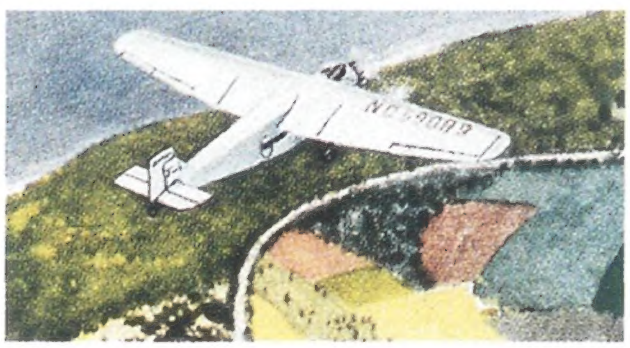

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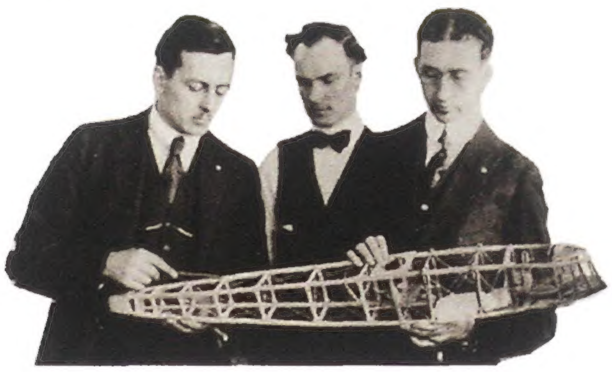

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"If it wasn't for my love of flying, I wouldn't be where I am today." *Allen Paulson*

While working as a teenage ranch hand, Allen Paulson got his first exposure to flying. "In order to make extra money, I'd wash planes for visiting barnstormers," recalls the Gulfstream Aerospace CEO. "One day I managed to talk one of the pilots into taking me for a ride. At about 2,000 feet, with the valley spread out below me, I felt that up there in that plane I could do anything."

Today, Paulson heads the world's largest corporate jet manufacturer. He's also been a ground mechanic, a flight engineer, and a test pilot. "You get a much better perspective on things when you've learned them from the ground up."

As captain of a company team of pilots, Paulson has set over 30 around-the-world international speed records in the *Gulfstream IV.* Currently, he is working on developing the world's first supersonic business jet. "This jet is going to be a real breakthrough," he says. "It's going to push corporate aviation into the twenty-first century."

Paulson's devotion to precise engineering and superb craftsmanship is also reflected in his choice of watch. The Rolex Oyster Perpetual. "Rolex makes watches the way I make airplanes—with an incredible attention to detail. That's why my Rolex is such a perfect watch for me."

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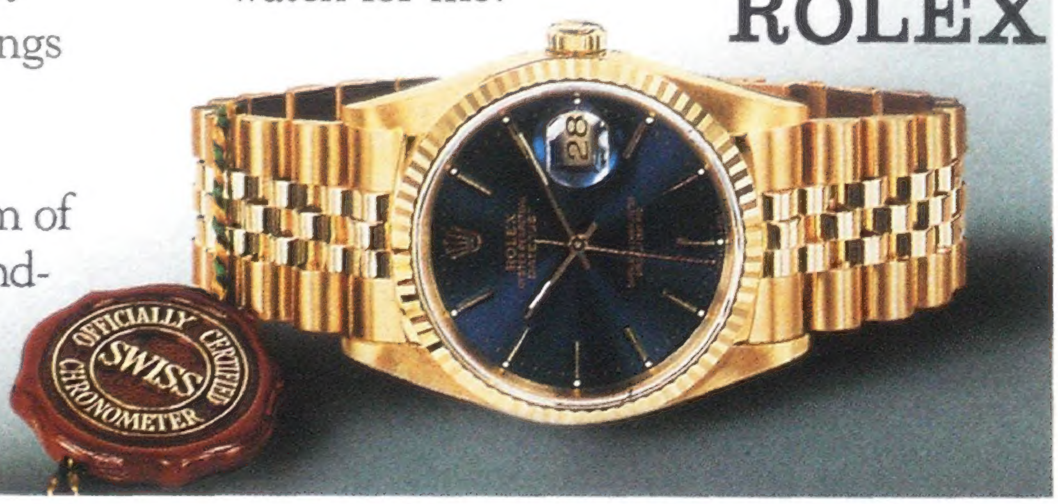

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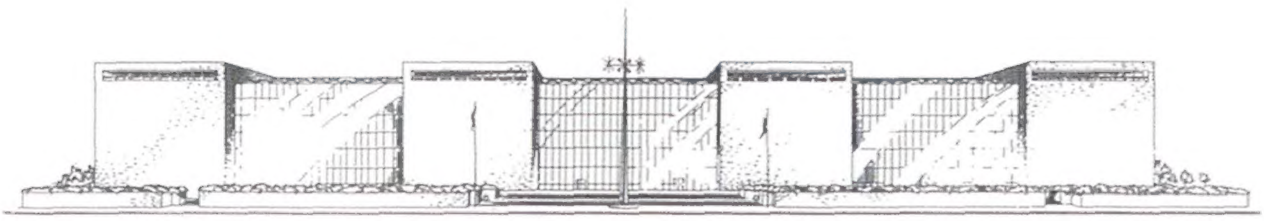

Are We Doing Our Job?

The National Air and Space Museum, like most of the Smithsonian Institution, is partially funded by Congress and partially supports itself through income from our educational films, planetarium shows, gift shops and restaurant, private donations, and other sources.

Our congressional appropriation suffices to provide for salaries, maintain exhibits, restore airplanes and spacecraft in our collections at a modest rate, and support archival and historical research guaranteeing the accuracy of our exhibits. But as congressional budgets have tightened, the Museum has increasingly gone to industry, foundations, and individual benefactors to raise funding for new galleries and films.

We pride ourselves on raising those funds on behalf of the public without having to ask the taxpayer for more. Not that we invariably succeed, but we are fortunate in having so many friends. They have helped us to open new galleries on topics of interest, such as the forthcoming "Where Next, Columbus?" exhibition, which is based on the best current engineering and humanistic thinking on space exploration in the centuries to come—an exhibition designed to show youngsters at the kindergarten through high school levels the challenges they could face in joining the next generation of space explorers. Complementing that will be the "How Things Fly" gallery, which is planned to open a year later and designed to explain the scientific and engineering principles of powered flight through the air, lighter-than-air craft, rockets, satellites, and spacecraft. That gallery is expected to include a variety of wind tunnels, subsonic as well as supersonic, with which youngsters can experiment.

This can be heady stuff for any kid fascinated by flying and exploration. And the solid physical and technical foundations underlying those galleries will be balanced by the comprehensive historical approach we have taken in such galleries as our retrospective "Legend, Memory and the Great War in the Air," which deals with World War I and fittingly opened last Veteran's (formerly Armistice) Day, November 11.

The Museum's approach matches an emphasis increasingly appreciated in the nation's leading engineering schools—namely, that our future engineers should be taught not just engineering but also the broader social impact and historical development of modern technologies. That approach is also featured in the Museum's wide-screen, IMAX-format film *Blue Planet*, which emphasizes the importance of ecological studies and environmental forecasting made possible through oceanic, atmospheric, and landmass surveillance from space.

I stress all these efforts because occasionally the Museum's requests for foundation or industry support are regretfully turned down with a note stating, "Our Board of Directors is dedicating its resources solely to science and technology education this year."

Does that mean we have failed to educate the eight million people visiting the Museum each year—one million of whom are under age 19? Or have we, just as seriously, failed to take our message to the people most concerned with science and technology education in America?

Recently, I visited one of the nation's wealthier philanthropists. After I had enthusiastically recounted all the directions the Museum is pursuing, he dryly responded, "I've been forward-looking all my life. I never look backward. Museums look backward. I never support museums." A brief attempt to sway him proved fruitless.

You win some and lose some. But I did want readers of *Air & Space/Smithsonian* to recognize how dedicated the Museum is to its educational goals, and how emphatically we look forward, with both realism and concern, to the impact of technology on our society, environment, and planet, and the prospects for ever-deeper exploration of space.

—Martin Harwit is the director of the National Air and Space Museum.

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Letters

Whodunit

To all those embroiled in the controversy over "Who Shot Down Admiral Yamamoto?" (February/March 1992), I have this suggestion: Grow up, boys. The event happened almost 50 years ago and most Americans today couldn't care less. Making such a big deal over who killed a brave man who fought for his country just as you fought for yours is unseemly if not childish. Lest there be any question of my qualifications for addressing this issue, I fought in World War II as a bomber pilot and like most veterans of that war, I have long since put it behind me. I suggest that the protagonists in this tiresome affair do the same.

Theodore R. Smith
Hot Springs Village, Arkansas

I was with the 13th Air Force as a B-25 pilot and well remember the stories concerning the downing of the Betty, but until reading your article, I never knew of the controversial circumstances surrounding the incident. Tom Huntington's brilliant writing took me back nearly 50 years and thrust me into the Bougainville area once again. I think it would be impossible after all this time to decide who was really responsible for downing Yamamoto's Betty. I vote for a draw, as the P-38 pilots may both have gotten in a few effective bursts.

James E. Cook
Columbia, South Carolina

It's too bad that two intelligent, rational fliers who were friends couldn't share the honor.

Robert Wynne
Mercer Island, Washington

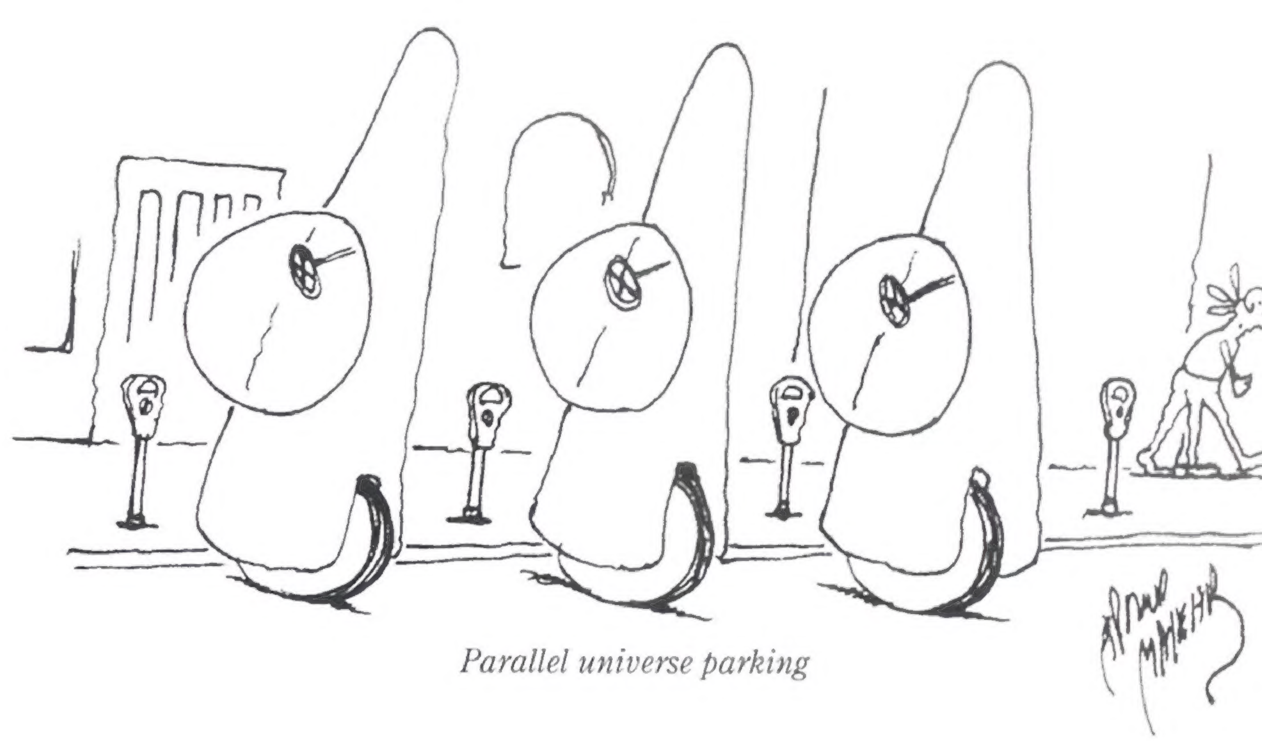
The bickering by Barber and Lanphier 40-plus years after the event took place is pathetic. They should be content with their place in history, a place thousands of World War II pilots would gladly have shared.

Anthony D. Schiller
Downers Grove, Illinois

I greatly enjoyed Tom Huntington's story, but why is there no mention of gun-camera footage? Surely the P-38s involved were equipped with cameras by that phase of the war.

Ken Cooper
Acton, Massachusetts

Tom Huntington replies: The airplanes were equipped with cameras, but unfortunately there was no film on Guadalcanal and no time to get any before the mission.



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The Stuntman

It gave me great pleasure to read "Rescue From Above" (February/March 1992) by Breck Henderson. My fondest memories from 22 years of military service are of the years I served as a pararescue officer, from 1965 to 1970. Working with such a breed of men is something I will never forget, and the habits and skills that I learned will never go away. For years after my retirement, I longed to continue using my pararescue skills, so in 1980 I renewed my skydiving license and improved my physical condition with diet and exercise. After receiving training, I became a movie stuntman in 1989. Thanks to my new career, I find myself continually rappelling, swimming, scuba diving, running, and parachuting. In addition, I've learned a new set of skills: high falls, stair falls, car hits, fire burns, driving cars and boats, and flying aircraft and paraplanes. I turned 62 in February and am enjoying my retirement more than I ever dreamed I would.

Major Peter A. Rundquist
U.S. Air Force (ret.)
Orlando, Florida

Anonymously Yours

Rex Hardy's *Callback* ("True Confessions," December 1991/January 1992) reminded me of the "Anon E. Mouse" column that used to appear in the Air Force monthly *Flying Safety.* The column provided jangle-nerved jocks an opportunity to rat on themselves without fear of censure by the big cheese. Why, I recall the time...

Dick Tokarz
Yorktown, Virginia

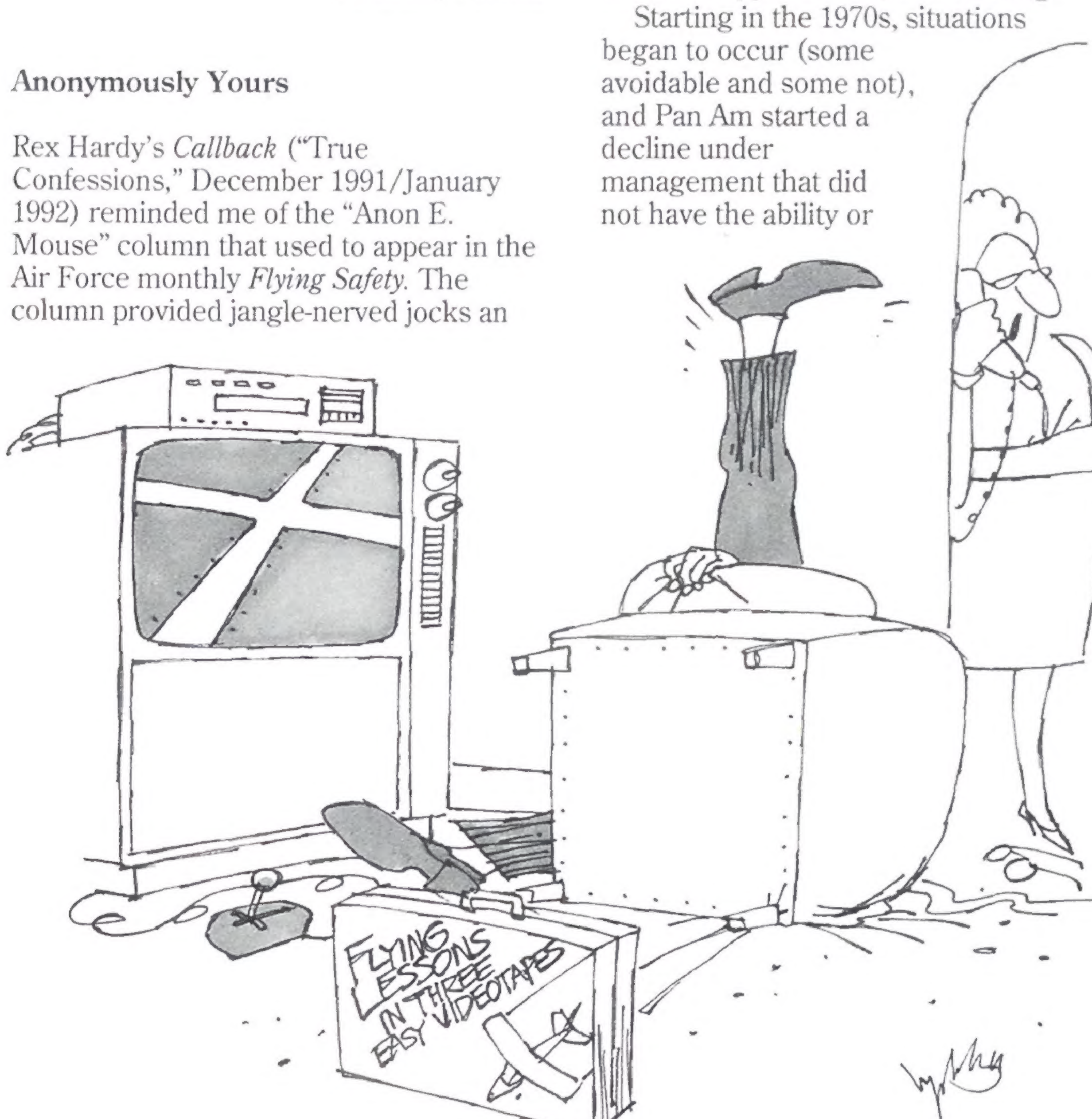
There Was Glory Before the Fall

"The Passing of a Pioneer" (February/March 1992) could have been your final tribute to what was a giant in the airline industry. Instead William Gregory downplayed Pan Am's accomplishments and stressed the management shortcomings of recent years. Let me tell you what Pan Am did in the early years of commercial aviation. We developed air routes and aerial communications equipment. We built sea- and landplane bases throughout Latin America and eventually all parts of the world. During World War II, Pan Am flew millions of miles over uncharted routes with military supplies, personnel, and mail. Whenever other countries were ravaged by floods, earthquakes, revolts, and other catastrophes, Pan Am flew in medical supplies, food, and clothing.

Starting in the 1970s, situations began to occur (some avoidable and some not), and Pan Am started a decline under management that did not have the ability or foresight of Juan Trippe to prevent the airline's eventual demise. I am not in favor of the government bailing out every company that suffers financial reverses, but it is strange that when Pan Am began to face the grim end, not one word was said nor one finger lifted in Washington to assist what was once the only carrier of the American flag throughout the entire world.

After trying for five years to get a job with Pan Am, I finally joined the company in January 1937; I retired 40 years later. It was a great company, and although I must admit that a small percentage of the personnel were deadbeats, Pan Am provided me with the opportunity to work with aviation experts who were capable and loyal.

E. Spencer Garrett
Aptos, California



"That was Henry. He just can't handle that turn into the downwind leg."

We Are Not Teetering

To my surprise, William Gregory characterizes Northwest Airlines as a "teetering" carrier, like TWA and Continental ("The Passing of a Pioneer," February/March 1992). Let me assure Mr. Gregory and all the readers that Northwest Airlines is not teetering. Unlike TWA, Northwest has not furloughed any of its workers. Unlike Continental, Northwest is expanding its route structure. And unlike TWA and Continental, Northwest is adding a total of over 100 new A320, A340, A330, B757, and B747-400 aircraft to its fleet in the next five years. But most importantly, we are not filing for Chapter 11 bankruptcy protection.

Captain William Alonso
Northwest Airlines
Deephaven, Minnesota

As an employee of Northwest, I must point out that it's true the airline has been burdened with a large debt load as a result of the acquisition by Wings Holdings, but the repayment of that debt is well ahead of schedule. Indeed, Northwest has the cash flow to pay all of its bills in full. Instead of laying off employees, Northwest plans to hire more than 1,500 flight attendants before the end of the year.

Paul L. Moffett
Lakeville, Minnesota

A Man From Mars

In "Dial-a-Planet" (Flights & Fancy, February/March 1992) Phil Scott missed

a spot. I am a resident of Mars. It's a small town in Pennsylvania. Our claim to fame was a huge apple grower whose apples were out of this world, but now the land is being developed into a housing complex. It's always fun when we Martians tell people where we're from because we get some mighty strange looks.

Bill Kopie
Mars, Pennsylvania

"Too derivative."

No Nukes!

I was distressed by the attitudes of scientists toward the safety issue in the "The Nuclear Option" by Gregg Herken (February/March 1992). To those who are developing this technology, I say it is irresponsible to knowingly release high levels of radiation into our environment. It is little surprise that those in the nuclear industry are coming out of the closet with plans for a nuclear rocket. With the end of the Cold War and the announcement that the United Sates will no longer produce nuclear warheads, many in the industry are scrambling for their jobs and struggling to come up with anything that will justify the billions of dollars that taxpayers have doled out over the years. Americans have grown up since they were introduced to "Your Friend, the Atom" in the 1950s. "John Q. Six-pack" will no longer allow people like Richard Burick to insult our intelligence with safety claims. Many Americans now know that because we did not evolve with highly radioactive isotopes in high concentrations in the

"Did you have to bring your stamp collection?"

environment, these materials pose severe risks to our health. The last thing the world needs is a flying Chernobyl. Nuclear power for spaceflight is not an option. Let us hope that this potentially threatening technology and its supporters go the way of the Cold War.

Anthony Erich Grass
Boise, Idaho

An Ernest Appraisal

The death of Ernest K. Gann saddened me deeply (Update, February/March 1992). As an aspiring writer-historian, I sent Gann a sample of my work after finding his address in a writers' directory. Not many authors of his stature would take the time to reply, much less read the stories, but Gann did. With a much-appreciated sense of humor, he told me I "would not supplant St. Exupéry." I still have the original letter with his signature and the stamped envelope dated June 1981. I now keep this treasure in a copy of *Fate Is the Hunter*. There are few great writers left who can recount their experiences as he could—the ranks grow thinner each year. He shall be sorely missed.

J. Patrick Doyle
Ogdensburg, New York

Correction

The first payload to be successfully recovered in mid-air was the Discovery 14 capsule, not Discovery 13 ("...and Satellite Fishing," In the Museum, December 1991/January 1992). The recovery took place on August 19, 1960.

We welcome comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

Unidentified Flying Object

Can you identify the aircraft in this photograph? The following comments were penciled on the back of the photo: "Shattuck, Cleveland, Ohio, 1913...think this is same motor Thompson Museum has at Cleveland." Is "Shattuck" the name of the man posing in front of the aircraft and engine? Where was the picture taken? Noteworthy is the engine, most likely a Kemp. If you can solve this mystery, send your response to: Air & Space/ Smithsonian, *Department ASP, 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. We received five responses to last issue's puzzler, but none gave us a positive identification. The hydroaeroplane in question is neither a Curtiss nor a Burgess-Dunne design, as some readers suggested.*

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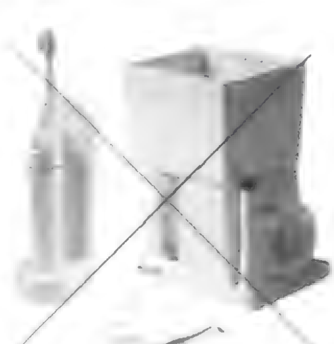

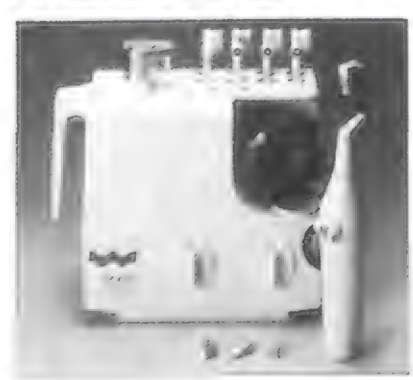

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NASA's Nest Egg

KEVIN RECHIN

Launch Complex 17-B at Cape Canaveral Air Force Station has hosted dozens of flight-bound payloads over the years. But none has been more delicate than a pair of eggs discovered at the Florida facility in early January, left by a feathered family that took advantage of the holiday lull and set up residence high atop the complex's service gantry.

When McDonnell Douglas mechanic Bruce Russell chanced upon the nest during a routine inspection on January 6, the irate mother, a sizable great horned owl, went on the defensive. "I saw it just in time to duck," Russell recalls. "It knocked my hardhat down over my eyes." The pad crew later posted a warning on the gantry: "Caution—Entering Owl Country."

The feisty bird might have been left in peace were it not for a Delta II rocket awaiting launch below it. So a few days later biologist Mark Mercadante and ornithologist Resee Collins gingerly climbed 150 feet to the nest and moved the eggs to safety. They also rescued a second pair of owl eggs found nearby, 90 feet high on Pad 46. "It's very unusual for them to have chosen such non-natural nest sites," notes Collins, a curator at Florida's Audubon Center for Birds of Prey.

Both of Pad 17's eggs had cracked after rolling around on the metal flooring; the less-damaged one was patched with glue and later produced a healthy chick. It's been named Navstar, after the Delta II's global positioning system navigation satellite payload.

—*J. Kelly Beatty*

An Astronomical Inheritance

It wasn't your usual classified ad. Last December, among the notices in the *Washington Post* for yard sales and used mowers, was an ad selling "moon dust." Steven Goodman, who placed it, swears the dust is the real thing, stuck to a four-inch piece of Scotch tape. No bids under $20,000, please.

NASA, meanwhile, says the dust belongs to the agency, not Goodman, and is prepared to get downright sticky about it.

Goodman, who lives in Dover, Delaware, recently found the tape with the gray specks while sorting through his father's papers. Edward Goodman, who died in 1972, got it while working for ILC, a company that builds spacesuits and cleans them on their return from missions. On April 22, 1971, Goodman purportedly ran the tape down the left leg of the suit Edgar Mitchell wore on the Apollo 14 mission.

Mitchell's suit eventually was given to

the Smithsonian Institution (currently it's on loan to the Swiss Museum of Transportation in Lucerne). "Some of these suits come back pretty dirty," says Lillian Kozloski, the Smithsonian expert on spacesuits. She says the dust could very well be the real thing.

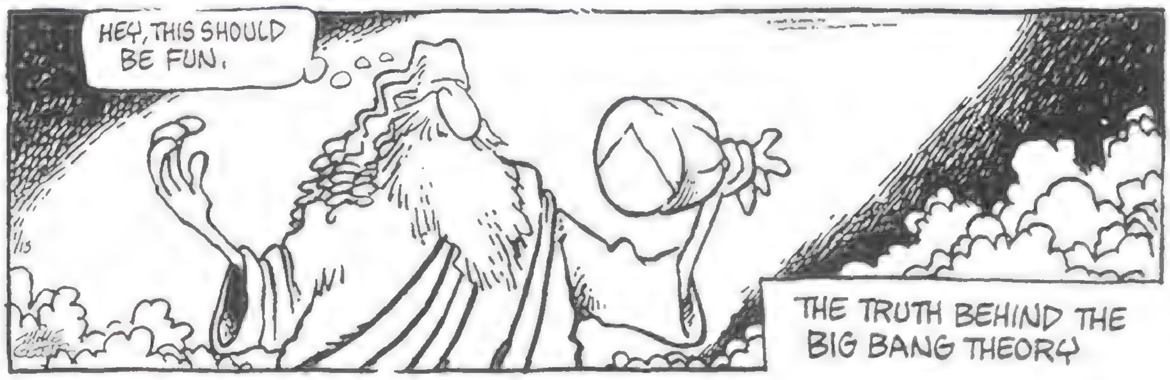
Goodman, 31, figures the sample could pay the tuition he needs to complete a degree in aviation maintenance. Hence the ad in the *Post*, which drew calls from as far away as Indonesia. Also calling was Alexandria, Virginia lawyer Keith Hallam, who now works with Goodman. Hallam believes the dust is abandoned material and therefore no longer belongs to NASA. "It's equivalent to sending your suit to the cleaner," he says. "You don't expect it back with a Baggie full of lint."

NASA, which would not return calls on the matter, won't decide what to do until the sample is authenticated. The dust is now in the hands of an expert for analysis (Goodman declines to reveal the name for fear of government confiscation).

Why does NASA worry about such a minuscule collection? Glenn Reynolds, a law professor at the University of Tennessee at Knoxville and author of the textbook *Outer Space: Problems of Law and Policy*, thinks the agency fears the creation of a market for lunar material. Perhaps, he says, they're concerned about setting a precedent for future Mars missions. "We could have an Andromeda Strain situation," says Reynolds, "if samples are snatched before they are quarantined."

Meanwhile, Hallam is scheming to set up a business selling other space material people have recently called him about: reentry foil, an astronaut's microfiche bible, pieces of spacesuits. And Steve Goodman is still trying to scrape up money for next semester.

—*John Ross*



TRIBUNE MEDIA SERVICES

While the American Astronomical Society met last January in Atlanta to announce findings on pulsars, white dwarf stars, and the latest Hubble telescope data on the Big Bang theory, cartoonist Mike Peters came up with a simplified explanation. (For more about the Big Bang, see "Ancient Whisper," page 54.)

Update

New Kaman Copter

Kaman Corporation tested its first new design in years last December at its Connecticut facility ("The Taming of the Copter," December 1990/January 1991). The company's Multimission Intermeshing Rotor helicopter, which has been swathed in secrecy during development, is designed for manned and unmanned military and civilian applications.

Update

Sailing Back to the Moon

In preparation for a race to the moon via solar sail (Soundings, August/September 1990), cosmonauts aboard the Mir space station will make a three-day test of an 82-foot-diameter sail late this year. Officials at the Institute of Space Research in Moscow envision an entry some 650 feet in diameter for the late-1990s moon race.

If U Cn Rd Ths U 2 Cn Fly

The F-8 Crusader slides in behind a bogey and fires on it. "Gunfighter 2, guns, guns, guns!" the pilot exclaims proudly. "I've got good news and bad news," ground control says. "It's good you made a quick kill, but it's bad you shot down your own flight leader."

In another sector, an A-4 Skyhawk makes an attack run, pulls up, and reports in. Ground control replies that the run was good, but he was supposed to bomb, not strafe, the target.

"We crank out top guns every hour," says Ed Bandy, owner of the Air Combat School in Arlington, Texas. "Why it takes the government so long is beyond me."

Two years ago Bandy bought two forward fuselages—one an F-8's, one an A-4's—from an aircraft parts dealer in Arizona, added over $100,000 worth of research, hydraulics, and video gear, and turned them into flight simulators. Air Combat pumps up its clients by suiting them up and training them in a video ground school, F-106 ejection seat trainer, and vertigo-inducing chair. An audio tape of their air combat dialogue is also included in the $70 one-and-a-half-hour package for two. The school has hosted military and civilian pilots, including a Japanese World War II veteran who flew Zeros, but the majority of Bandy's clients are simply *Top Gun* fans.

Gunfighter 2, or Siobhan Farr, a management consultant from Dallas, gave her husband Karl Henderson (Mongoose 2) the session for Christmas. "He plays the flight simulator games all of the time," she says. "He's been waiting for this."

Henderson, a 28-year-old computer software designer, says, "It's hard to say if I'll do any good. I don't want to start this thing with a big mouth."

Both pilots engage targets in a 30-minute flight that culminates in a dogfight. Farr starts slowly, but warms up after a few kills. Henderson immediately engages the enemy. After refueling, bomb runs, and in-flight emergencies, it's time for the finale. Farr already owes Henderson dinner for shooting down the flight leader.

"You can run but you can't hide, Mongoose," Farr yells as she attacks. Ground control calls it a kill. After several attacks, Henderson declares an emergency and wants to eject.

"How serious is it?" ground control asks. "It's probably a short in the warning light. Stay in the fight." He does, eventually scoring a kill.

After the dust settles, Henderson says the best part was shooting down his wife. While they remove their flight gear, Bandy tells them about a new scenario that offers carrier takeoffs, radar intercepts, and exploding targets. Future plans include an F-111 cockpit for bombing missions. "If we had a bigger place we could get some fighters for taxiing or maybe an F-104 modified to do an actual takeoff roll," Bandy says.

—*Glen Golightly*

Bowled Over

"We've been planning six months for Superbowl weekend," said Emmett O'Brien, general manager of the aviation service outfit Page Avjet. That planning was evident, with Page smoothly handling over 200 aircraft that flew into Minneapolis/St. Paul airport for Superbowl XXVI last January 26, with some 50 arriving just before kickoff.

Taxiway Delta was reserved as a lot for the 106 aircraft that parked near Page. Fortune 500 companies were well represented by Gulfstream G-IVs, Cessna Citations, and Rockwell Sabreliners. Donald Trump enjoyed the game—and the charter business, with a number of Trump 727s booked. A stream of limos flowed through the arrival section, including the hot dog-shaped Oscar Mayer Weinermobile, which met executives from the lunchmeat company at the gate.

Page served up a big buffet for the corporate pilots and set up big-screen TVs so that everyone could enjoy the game. Unfortunately, many of the crews missed the ending—fans at the stadium opted for early departures, given Washington's lopsided lead over Buffalo in the first half.

The Federal Aviation Administration had issued a five-day bulletin warning pilots to beware of "a significant amount of wake turbulence…due to the large number of heavy aircraft operating within 30 miles." Minneapolis air traffic controllers efficiently handled Sunday evening's mass exodus. Stragglers began arriving at 4 a.m. for Monday morning departures, and Taxiway Delta was once more a taxiway by early afternoon.

—*Jerry Bernstein*

Update

Satellites Spy a Lost City

Geologists, imaging specialists, and remote sensing scientists using Landsat and SPOT images and shuttle imaging radar have discovered what may be the ruins of the lost city of Ubar in Oman ("Looking Down on History," August/September 1988). In 1984 near-infrared imagery had revealed the remains of caravan routes under the sands of the Arabian Peninsula; last November, satellite imagery led a team to tracks leading to a well and an octagonal structure that may have been part of a distribution center for frankincense trade routes some 4,000 years ago.

Take This Job and …

Disgruntled flight controllers at the once-secret Mission Control Center outside Moscow have made a new contribution to the openness of *glasnost.* Last January, with reporters on hand for the linking of an automated Progress supply craft to the Mir space station, controllers draped protest banners on the center's walls and computer consoles. "Our work is cosmic," read one, "but our pay is comic."

Civilian controllers typically earn only $5 to $10 a month, roughly two-thirds the average worker's salary and hardly enough to keep pace with the rapidly rising costs in post-Gorbachev Russia. However, this mix of engineers and cosmonauts often receive other benefits—upgraded apartments, cars, and food—beyond the reach of rank-and-file Muscovites. "They have a ton of perks," says cosmonaut aficionado Michael Cassutt.

Meanwhile, Mir sails on, unaffected by the ground-bound grousing, although one cosmonaut aboard had his own reasons to complain. Sergei Krikalyov (see "Inside Star City," June/July 1990), whose occupation began last May, was effectively stranded in orbit since last October. That month, space officials sent a Kazakh cosmonaut on a politically expedient but hastily planned visit to Mir, but he was not qualified to replace Krikalyov. At last word the longtime tenant was due back sometime in March. In support of his co-workers, perhaps Krikalyov will put in a claim for five months' overtime.

—*J. Kelly Beatty*

MARGARET SCOTT

Honk If You Love Dassault

Marcel Dassault, the French aviation pioneer, has been immortalized in stone. He didn't get just a statue—he got a whole traffic circle, and on Paris' Champs-Élysées, no less. Commemorating the 100th anniversary of the aviation pioneer's birth, the Rond-Point des Champs-Élysées was renamed the Rond-Point des Champs-Élysées-Marcel Dassault last January 22. Celebrities from industry, politics, and showbiz were on hand, flanked by rows of riot police. Overlooking it all were the posh headquarters that Dassault had bought in 1952.

It's a lot of space for one man, but the empire builder covered a lot of ground—and air—in his lifetime. Father of the venerable Mirage fighter, Dassault also toyed with banking, publishing, construction, and moviemaking, and before his death in 1986, he managed to see his precious Rafale fighter program get airborne.

He also dabbled in politics, and that part of his legacy now looks weakest. Dassault Aviation has been viewed as the French government's private arsenal, but now the Dassault political clout is withering. The French state has been a shareholder in Dassault Aviation since the Socialists came to power in 1981 and threatened to nationalize the company. Dassault persuaded the government to merely hold a controlling interest, making a gift of the necessary

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shares from his own pocket. The government can turn the Dassault family's holdings into a minority share any time it wants.

Since Marcel's death, aircraft orders have dropped 25 percent. Worst of all, there hasn't been a military export order since 1986, and industry watchers doubt that the civil branch's Falcon 2000 program can make up for it.

As Alexandra Schwartzbrod, the author of a recent book on Dassault, writes, "Post-Mitterrand will be fatal to the Dassault family." The French president leaves office in 1995.

"The woman who wrote that is crazy," says Marcel's son Serge, chairman of Dassault. "All we have to do is keep making good airplanes. We'll be all right."

In the meantime, Dassault is betting the farm on a new Mirage 2000-5 program while praying the airplane won't live up to its name. The founder's heirs are hoping the Mirage will be a real source of cash—not just an optical illusion.

—Joshua Jampol

No Dessert Until You Finish Your Mission

DAVID CLARK

A space shuttle countdown wouldn't be complete without the breakfast photo opportunity. That's when smiling astronauts feign their last pre-mission Earthly meal around a table adorned with china, crystal, and sterling. The centerpiece is always a cake emblazoned with the crew's mission emblem. After the cameras are gone, the fancy dishes, never sullied, are removed. But the cake is saved as a memento to be savored by the crew after the flight, and a tradition so honored that the list of bakers is guarded like a military secret.

"The cake is frozen after you see it on TV and it is flown back here to Houston," says Barbara Schwartz, a spokeswoman for the astronauts. "It remains frozen here until they all have a get-together when the mission's over." In case of a lengthy launch delay, the cake is thrown out and a new one is baked.

NASA's Nancy Gunter, who is something like a housemother to the elite fraternity of men and women who stop at the Kennedy Space Center en route to orbit, is the cake procurer. She baked the first one for *Columbia* fliers John Young and Robert Crippen in April 1981. Now she's compiled a list of bakers and spreads the business around. The day before the January 22 *Discovery* launch, Gunter commissioned the Publix bakery in Titusville, Florida, to produce its $25.75 special, a 16- by 12-inch marble cake with butter cream frosting that feeds 50.

It took the threat of a First Amendment challenge to persuade Gunter to reveal her latest baker. "It's a security issue," says Kennedy spokesman Dick Young.

—Beth Dickey

A Son of Daedalus—With Sturdier Wings

Last August, at a party at Manassas, Virginia's municipal airport, a new company called Aurora Flight Sciences unveiled a remotely piloted research aircraft called Perseus. Some of the names and faces at the party were familiar: many of Aurora's founders were members of the Massachusetts Institute of Technology team that designed and built Daedalus, a human-powered aircraft that made a 74-mile flight across the Sea of Crete in 1988 ("Hover Story" June/July 1988). Perseus resembles Daedalus in superficial ways but is completely different in that its mission is to study the upper atmosphere.

High-altitude balloons have long been a mainstay for such studies, but balloons have drawbacks: they are at the mercy of the winds, and they "outgas," or leak minute amounts of gas that contaminate instruments sampling the atmosphere. Perseus carries its instrument payload in the nose, where sensors will sniff

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uncontaminated air, and the aircraft can fly anywhere scientists point it.

Perseus offers design challenges radically different from those of Daedalus. The Daedalus team built a low-altitude airplane flying 15 mph at sea level. At Perseus' intended altitude of more than 80,000 feet, an indicated airspeed of 15 mph becomes a true airspeed of 200 mph due to lower air density. Daedalus was powered by a bicyclist; Perseus will use a rotary engine based on the Wankel design made famous by Mazda cars. Instead of mixing fuel with air, burning it, and dumping the exhaust overboard, the Perseus engine will burn fuel mixed with oxygen from an onboard tank. The exhaust will recycle back into the engine, where more fuel and oxygen are added. The engine can thereby maintain very high pressure even at high altitude. Only small amounts of engine gases are vented overboard.

Early last November, a proof-of-concept aircraft successfully flew at El Mirage, California. The test craft lacked the 15-foot propeller that will power the final version, but it evaluated the flight control system and remote piloting.

At the August hangar party, Harvard professor Jim Anderson, one of the first atmospheric researchers tapped to use Perseus, explained that the precise nature of the processes driving such global phenomena as atmospheric warming, ozone depletion, and severe storms are not well understood. "We've never had the opportunity to use a platform that can get not only to high altitudes but can fly in a directed fashion much as a robot would," he said. "[Detecting upper atmospheric chemical processes is] very similar to a medical diagnosis. Satellites are very useful for broad-ranging observations of climatology and morphology. If you want to diagnose the disease, [Perseus] is the MRI [magnetic resonance imager] of atmospheric science.... You have to have the smoking gun, and to gather those data, this is the only platform that can really do that." If Perseus can live up to its design promises, NASA will buy two for research. Anderson hopes for his first Perseus flight sometime in 1994.

—George C. Larson

Promise Me the Moon

Like so many people who saw *2001: A Space Odyssey* at an impressionable age, Barry Epstein knew he would go to the moon one day. He'd fly in an elegant Pan American "space clipper," complete with Velcro-booted stewardesses, just like in the movie. He even had reservations—numbers 24337 and 42879, to be exact—by virtue of membership in Pan Am's "First Moon Flights" club, a widely successful promotion that was still making headlines in the wake of the company's demise last year.

"I remember being disappointed that I got such high numbers," says Epstein, 35, who now works for NASA promoting space station Freedom. "I hadn't been on an airplane yet, and I wasn't sure I would ever have the money to fly on a space plane. But I knew I wanted to be in line."

So did tens of thousands of other people in the late '60s and early '70s, when routine commercial space travel seemed just around the corner. Inspired by the prominent use of Pan Am logos in *2001*, the airline capitalized on its tradition of booking historic first flights by starting a club that ostensibly guaranteed members a reservation when Pan Am started service to the moon.

"We took our first reservation for the moon from an Austrian journalist in 1965," says Jeff Kriendler, Pan Am's last vice president of corporate communications. "But the list wasn't very active until the release of *2001* and the Apollo moon landing. We rode on the coattails of those events by starting this club, which was in effect a marketing program saying how wide our expanse was."

Club members received no more than a numbered card emblazoned with a lunar landscape, but the response was phenomenal. By the time it dropped the program in March 1971, Pan Am had issued 93,001 cards, and it could have issued a lot more. "We started the club as somewhat of a lark, but it became an administrative nightmare," Kriendler says. "This was before we had the kind of computer technology available today, and the paperwork grew out of control."

To judge from the stories and letters that appeared after Pan Am folded, time did nothing to diminish aspiring space travelers' hopes of getting a moon flight. Many had saved their cards; Epstein's was reproduced in the *Washington Post* alongside a letter he penned lamenting his lost opportunity. "I wrote because this was a very significant commitment that the company made, and if Pan Am can't do it, I don't know who can," he says, adding glumly, "The future just isn't what it used to be."

—Frank Kuznik

Update

HOTOL Gets a Boost

A model of a scaled-back version of the British HOTOL spaceplane mated to an Antonov transport aircraft model began wind tunnel separation testing last January in a Russian aero-hydrodynamics facility. Equipped with rocket engines in lieu of Alan Bond's air-breathing/rocket engine ("The HOTOL Man," December 1988/January 1989), the less elegant design would be launched to orbit from an An-225 aircraft.

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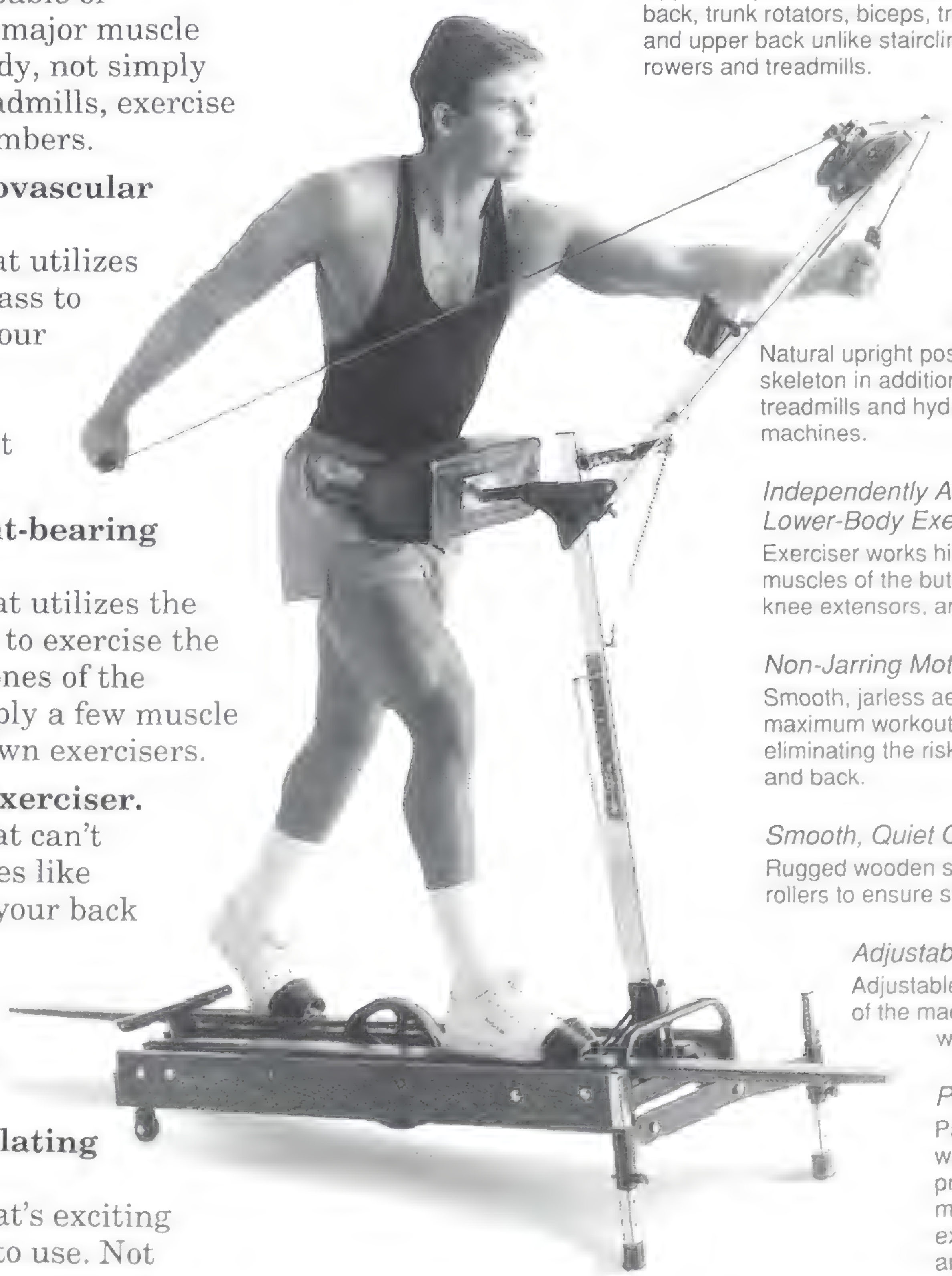

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This Old Starship


MARK AVINO

A major exhibit devoted to the television show (and subsequent movie series) Star Trek recently opened at the National Air and Space Museum. It should please all trekkies (or "trekkers," as the fans often prefer). The exhibit, scheduled to run through September 7, includes 80 artifacts, from Mr. Spock's Vulcan ears to the newly refurbished original model of the Starship *Enterprise*.

Since it was donated to the Museum by Paramount Pictures in 1974, the *Enterprise* model has been displayed in several exhibits, most recently above the entrance to the Rocketry and Space Flight gallery. It measures 11 feet in length and weighs 200 pounds. As a technician at the Museum's Paul E. Garber Facility in Suitland, Maryland, I was assigned to monitor the restoration of the model.

The challenge would be to make the model's plastic, wood, and rolled-steel pipe construction look like new, while at the same time keeping the original paint intact. The paint, which was cracking, would require the most attention. Over the years a streaking effect, which had been added to create a weathered look, had changed the model's color from gray to green. Some surface areas had also suffered stress cracks and warping. In addition, the *Enterprise* would require a new lighting system.

The restoration project started with a fact finding mission to Los Angeles that I undertook with professional model maker Ed Miarecki. We wanted to talk with the people who had designed, built, and filmed the original model. First we tracked down designer Walter "Matt" Jeffries. He provided us with historical background. He also told us that the starship's insignia, NCC 1701, came from his 1935 Waco airplane.

Our next stop was the tiny Production Models Shop in nearby Glendale. In 1964 its owners, Volmer Jensen, Mel Keys, and Vern Sion, had constructed the model starship for the original television series. Building materials for the model had cost about $600.

We also collected as many photographs of the model as we could find, because the *Enterprise* had evolved between the filming of the two pilot episodes and the show's premiere on September 8, 1966. It even kept evolving through the series' three-year run. The Howard Anderson Company filmed the model for Paramount, and Howard Anderson Jr., told us that the art department continued to add little details throughout the production. (The exception was the left side of the model, which, because it was never filmed, always remained unadorned.)

After a week of running around L.A., we consulted with the Smithsonian's Conservation Analytical Laboratory on how to restore the model and also maintain its historical integrity. The decision was made to restore the model to its appearance in the last episode, "Turnabout Intruder."

The restoration required six weeks of intensive labor, with Miarecki working 12-hour days in a Springfield, Massachusetts garage he had converted into a model shop. I checked in periodically by telephone. If things weren't going well I often received a dose of profanity. On one occasion I asked Miarecki if *anything* was going right and he replied that he had just discovered the origin of the primer coat on the *Enterprise*: it was a Ford truck gray from 1969.

The work was clearly worth it. I'd like to think that Captain Kirk himself would be proud to see his Starship transformed from TV prop to pristine historical artifact.

—Ken Isbell

Big Thoughts for Little Folk

"Thanks astrophysicist dude!! Thanks!" So reads a piece of fan mail that Jeff Goldstein received from a sixth grade admirer. Goldstein, a researcher at the Museum's laboratory for astrophysics, has become a popular lecturer at Washington, D.C.-area schools, where he gives a talk entitled "How Big Is Big?" that takes listeners on an exploration of the universe.

On a gray, rainy day last January, Goldstein arrived at a private elementary school in Reston, Virginia, where a group of 75 students sat on the carpeted floor of a large classroom. "Now I could start off by telling you exactly what I do and how I do it," said Goldstein, "but I think it would be better to take you on a journey." He reached into his black bag and extracted his props: a basketball, two oranges, a Ping-Pong ball, and a pin. Using each of these common items to represent a celestial body, the astrophysicist took his listeners beyond the solar system, through clusters of galaxies, and finally all the way back to the Big Bang.

CAROLYN RUSSO

"I spend a lot of time with kids at the elementary and middle level because that's where it starts," says Goldstein. "You want to start the curiosity going. You want to ignite interest in science and technology." He hopes that exposing kids to science in an entertaining fashion will make them "yearn to learn more, rather than feel it's a chore or a duty."

At Reston, Goldstein started off by asking a boy named George to hold an orange. Then he instructed the children to close their eyes and picture the orange, then two oranges, then three. Finally he asked them to picture 47 separate oranges. "It's kind of hard," said one child.

Goldstein's point is that it's difficult for the mind to imagine large numbers, such as the 93 million miles that separate the sun and Earth. "You've got to feel facts," said Goldstein. Pointing out that it's about 150 miles between Reston and Philadelphia, he asked, "Well, how is it that we know what 150 miles means? It's three hours in a car. How would you like to go three hours in the car without a bathroom break?"

"Oh, geez!" said one kid.

"You can feel three hours in the car?" asked Goldstein.

"Yes," said the class.

"You know what three hours in a car means," he continued, "and because you know what three hours in a car means, you know what 150 miles means."

Later, Goldstein helped the children comprehend the distance between the sun and the next nearest star, Proxima Centauri. He took one orange and gave another to a boy named C.J. The kids were amazed to learn that at this scale, C.J. would have to go all the way to Florida to accurately represent the distance between the sun and Proxima Centauri.

By the end of the lecture, the students could appreciate the vastness of the universe, which Goldstein illustrated by pulling a copy of Dr. Seuss' *Horton Hears a Who!* out of the black bag. "We're the Whos of Whoville, guys," he said. "We're a speck of dust and we're saying, 'We're here! We're here!' "

—*Diane Tedeschi*

Winging the Lecture

Being a Washington, D.C. institution, the Museum sometimes reflects the small-town character of its home city. It did so one day last February, when Ted Robinson stood in for a friend who was unable to give the scheduled noontime lecture. Robinson, a Federal Aviation Administration offical, Tuskegee airman, and former visiting historian at the Museum, faced a small audience: three.

As it happened, one of the three assembled in the Museum's briefing room was Solomon P. Hamilton III. He had just happened to stop by the Museum to show a friend his photographs from the annual convention of Negro Airmen International, an organization of which Robinson is a long-standing member. Their reminiscences about the black aviators in that group entertained the two others who had shown up for the lecture.

NAI was founded in 1967 as a way for

Artifacts

CAROLYN RUSSO

What is perhaps the largest airplane tire ever made can currently be found at the Museum's Paul E. Garber Facility. Weighing 1,320 pounds and measuring 110 inches in diameter, the tire belonged to the prototype of the Consolidated-Vultee B-36. When the airplane made its maiden flight in August 1946 it was the largest aircraft ever flown. However, there was a minor problem: the prototype weighed so much that it cracked concrete runways. The landing gear of the B-36 was modified to redistribute the weight on four smaller wheels. Eventually the strategic bomber was replaced by the Boeing B-52.

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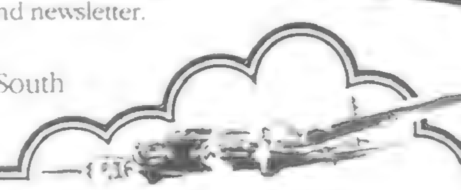

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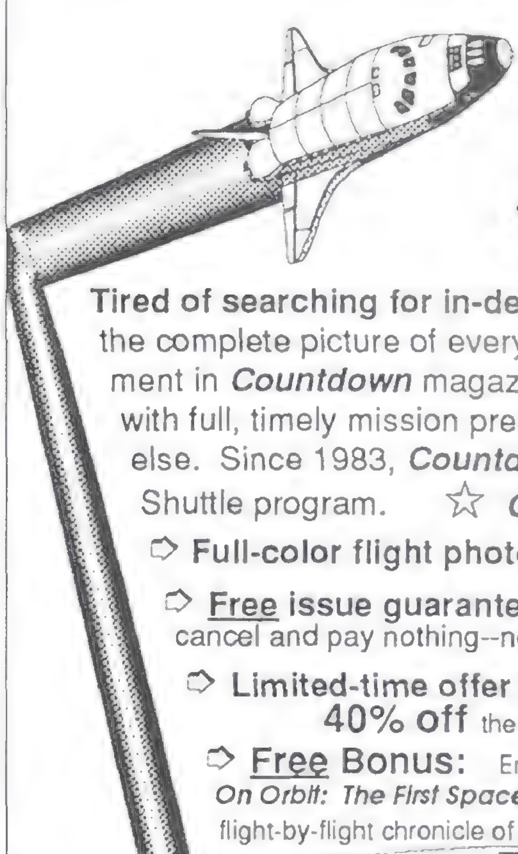

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its members to share flying experiences and advice, as well as to help—and possibly inspire—young black people to learn to fly. In 1979 the Washington chapter held a reception in the Museum to honor six pioneers of black aviation: C. Alfred "Chief" Anderson (who taught many at Alabama's Tuskegee Institute to fly and was the first black to become a commercial airline pilot), Cornelius Coffey, John Greene Jr., Lewis Jackson, Albert E. Forsythe, and Willa Brown—all household names to NAI members.

"Don Lopez and Paul Garber came to the reception," Robinson recalled, referring to two household names at the Museum. "This was the first time that people at the Museum realized that black aviation pre-existed World War II," recalled Robinson. And, he said, this chance encounter between aviation greats led to the Black Wings exhibit on the Museum's second floor. The exhibit of memorabilia and photographs, some of them stunning, chronicles the struggle and accomplishment of a group that, since Eugene Jacques Bullard moved to France in 1916 to get a pilot's license, was determined to get access to the air.

Finally, Hamilton remarked on the good fortune of running into an editor from this magazine and suggested publishing a notice of the NAI annual fly-in, the largest gathering of black aviators in the world. As it has for the past 18 years, it will take place at the Tuskegee Municipal Airport on Memorial Day weekend (see Calendar, p. 86).

—*Linda Shiner*

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700.

Museum Hours Most Smithsonian museums are open 10 a.m. to 5:30 p.m. daily. From April 13 to April 24, the National Air and Space Museum, National Museum of American History, and National Museum of Natural History will be open 9:30 a.m. to 7:30 p.m.

New Exhibit "Star Trek." This major exhibit includes costumes and props and will feature TV episodes. Flight and the Arts gallery. (See box, right.)

Lecture Series "Space Voyages Into the 21st Century and Beyond." This six-part series, sponsored by the Resident Associate Program, starts on May 14 and will feature congressmen, space

scientists, and astronauts. RAP members $70, non-members $104. Location to be announced, 8 p.m.

Open House "Wings and Things," at the National Air and Space Museum's Paul E. Garber Preservation, Restoration and Storage Facility, Suitland, Maryland. April 25 and 26, 10 a.m. to 3 p.m.

April 1 Exploring Space Lecture Series: "Early Results from the Compton Gamma Ray Observatory." Neil Gehrels, Goddard Space Flight Center, Greenbelt, MD. Einstein Planetarium, 7:30 p.m.

April 4 Monthly Sky Lecture: "Searching for Planet X." Robert Harrington, U.S. Naval Observatory. Einstein Planetarium, 9:30 a.m.

April 9 General Electric Aviation Lecture: "The Doolittle Raid." C.V. Glines, co-author of General Jimmy Doolittle's autobiography (*I Could Never Be So Lucky Again*), plus four members of the raid. Langley Theater, 8 p.m.

April 10 Film: *Thirty Seconds Over Tokyo.* Langley Theater, 8 p.m.

May 2 Resident Associate Program Lecture: "Meet the Astronauts" will include six shuttle crew members who recently deployed the Upper Atmosphere Research Satellite. Langley Theater, 9 a.m. RAP members $7, non-members $8.

May 13 Exploring Space Lecture: "Neutrino Astronomy." Virginia Trimble, University of Maryland. Einstein Planetarium, 7:30 p.m.

May 21 Charles E. Lindbergh Memorial Lecture: "A Fighter Pilot's Story." Lt. Gen. William Earl Brown, USAF (ret.). Langley Theater, 8 p.m.

STAR TREK: How to Obtain Passes to Visit the Exhibition
A pass system is in effect on every Friday, Saturday, and Sunday and every day from April 13 to 24 and June 15 to September 7. All visitors, regardless of age, must have a pass to enter. Passes (4 per person maximum) may be obtained at no cost at the Museum's south lobby 15 minutes before opening. Advance passes may be obtained through area Ticketmaster outlets. For recorded information, telephone (202) 786-2122.

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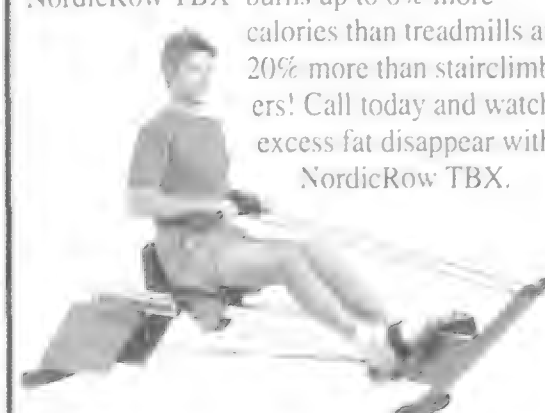

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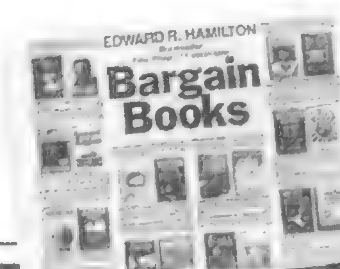

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Cruising With Regulus

Those who followed the early news from the Gulf war could not help noticing the prominent role played by U.S. cruise missiles, especially the Navy's Tomahawk. Essentially unmanned miniature aircraft, these weapons have the ability to race in at low altitude, evade radar, and strike enemy targets with unprecedented accuracy. The Tomahawks are launched with the aid of a rocket booster and sustained by the power of a small air-breathing jet engine. All very impressive—but did you know that we'd tried this technology before?

The military developed its first generation of cruise missiles during the 1940s and '50s. These craft were monstrous compared with today's models. While the Tomahawk weighs in at less than two tons, the Regulus I, designed in the late 1940s for the U.S. Navy, was more than four times heavier.

Those weighty early cruise missiles created equally weighty problems for those of us involved in their development. Test missions were dicey affairs. Many of us went prematurely gray, and we gulped down antacids all day long.

ILLUSTRATIONS BY RICHARD THOMPSON

In 1957, I signed on to the Regulus I project at the Naval Air Missile Test Center at Point Mugu, California (and at nearby Port Hueneme). My job was to advise on the care and feeding of the missile's turbojet engine.

In addition to its engine, the Regulus required two solid rocket boosters, each furnishing 33,000 pounds of thrust for about four and a half seconds. The bird had to be lofted from a rail launcher elevated to about 35 degrees.

For one launch exercise I was briefly assigned to a heavy cruiser named the USS *Helena*. The ship had been modified to accommodate and launch the Regulus, and these modifications and others made the ship extremely top-heavy. It was notorious for its slow and dramatic rolling motion.

The Regulus missiles were stored in an area right over the ship's huge propellers. When I went down there to introduce myself to the missile crew and help with any problems, I could not believe the din from those thrashing, cavitating screws. The shaking was so strong that if I tried standing in one place, I was slowly vibrated across the floor.

Several sailors were busily working on the missiles, while another was engaged in some demanding task at the control console. It was odd that the man at the console seemed so busy—no launch was in progress. Curious, I walked over and saw he was clutching a screwdriver and going across the panel from one screw to another. Each instrument in the panel was secured by four screws, and the ship's propellers were causing such thunderous vibrations that every screw was turning counterclockwise. As fast as he could tighten one, others spun outward, eventually clattering out onto the console table.

The sailor seemed to be enjoying his challenge. It was a good thing; I think that was his sole job.

Occasionally, the Regulus launch pad rails had to be checked to ensure they provided the proper launch dynamics. For this we used a cube of concrete weighing seven tons, the same weight as the Regulus. The cube was equipped with two solid rocket boosters, and periodically we would go through a countdown and launch it. The boob cube would fly several hundred feet up, then crash into Mugu Lagoon, startling nearby gulls into a raucous squawking and flapping.

On one occasion, I was escorting a visiting engineer from my company around the base and showing him the sights. We were about 600 yards from the launch pad when I saw flashing lights and Marine sentries posted in their positions. A launch was imminent. I looked closer at what was loaded on the rails. It was that dumb hunk of concrete.

Suddenly I had an inspiration. I turned to my visitor and pointed out the cube. Look, I remarked, they were about to launch our newest satellite.

He stared at the pad. But that was a cube, he protested. Weren't satellites supposed to be streamlined?

I explained that the scientists had determined that streamlining wasn't necessary after all: during the initial phase of the launch, all satellites travel relatively slowly, and by the time the block's velocity had increased, it would be far above the denser air.

That shut him up, though he continued to peer at the payload with a confused expression. But wasn't that a *concrete* block? he asked after a minute.

I told him that concrete was far cheaper and stronger than the sophisticated materials used previously, and anyway, things in space are weightless, so it didn't matter whether you used concrete or clarinet reeds.

Just then a nearby loudspeaker crackled to life, and we heard the familiar "Nine, eight, seven, six..." We watched as the boosters let out a roar and the whole contraption began rising. Then everything was obscured by smoke. I pointed to the sky and traced an imaginary trajectory. "Do you see it?" I screamed.

The engineer was smiling radiantly. "I see it!" he yelled back, "I see it! Look at that S.O.B. go!"

The Regulus was made in three variations: two could be controlled from the ground by radio, but the third—the TM, or Tactical Missile—had only on-board guidance. Moreover, the TM, unlike the other two models, had no landing gear. Once it was launched, you could neither control it nor retrieve it.

The TM was designed to carry a nuclear device. However, on launches from Point Mugu, it carried only a portion of one. I am unable to tell you just which portion; I was never informed, not having the "need to know." And you didn't get anywhere near a missile so equipped unless you had clearance from the Atomic Energy Commission.

Though I tried repeatedly, I could never get clearance. That proved a major inconvenience, both on the pad and off. Whenever the Regulus was ready for

launch and the engine developed problems, I was hurriedly summoned, but because I didn't have clearance, I often had to troubleshoot by phone.

One day I noticed that dozens of extra observers had gathered for a TM launch. I didn't know what the mission was, but it appeared to be an important one.

Just then my phone rang. The engine was torching—flames were intermittently shooting out of the turbine. Since the missile carried part of a nuclear device, I did what I'd done hundreds of times before: I hurried down to the blockhouse located several hundred yards from the launch pad and grabbed a big pair of binoculars. While talking on the phone to the launch crew, I had them go through the various power settings while raising and lowering the launcher rails so I could see up the engine's tailpipe.

After some minutes of observation I told the launch crew that the engine was working well enough to launch. I turned to the rest of the multitude in the blockhouse, who were chattering among themselves and, via radio, to the crew at the launch pad. It was then that I heard someone say something about flying over a populated area. Populated area?

I had thought the thing was going to fly straight out to sea—that was the customary mission. But it turned out that this missile was to veer to the south, flying off the California coastline to a point just north of Oceanside. At this spot, it was to head east for several minutes. Once it had reached the Salton Sea, about 85 miles inland, it would dive in, its mission complete.

On a nearby table, I spotted a plotter that moved a pen to draw the missile's course over a map of the area. I intended to follow this whole thing very closely.

The Regulus was launched. It climbed uneventfully.

Soon the pen on the map came to life. I saw it turn south, just as scheduled, and begin wending its way parallel to the coast. Then it turned inland. About one minute later the pen stopped. The missile was directly over downtown Oceanside.

After a moment the pen started moving again, making little football-shaped squiggles. I looked up at the telemetry experts. Their faces were blank. In my mind's eye I saw a pair of wings flapping, carrying a singed, smoking burden labeled "Career."

The pen abruptly zoomed some inches, then serenely resumed its designated course toward the Salton Sea. "Telemetering blackout," the experts said blandly. The TM's mission was completed without incident.

At one point, Congress threatened to cancel the Regulus program, so an inspirational junket was arranged to fly some congressmen out to the Barbers Point Naval Air Station in Hawaii.

Bleachers were set up near the runway. The plan was to have a bright red Regulus make a low pass right in front of the guests, wowing them with its control and speed.

Right on schedule, the Regulus made its approach. But to the horror of the event planners, the bird suddenly veered left, rolled over on its back, and zoomed behind the bleachers in inverted flight.

The congressmen were delighted with this clever demonstration of agility. Back in Washington, funding was restored.

I was reminded of this incident when I read a report that a Tomahawk launched from a warship in the Gulf of Mexico last winter flew 50 miles wide of its target, landing outside Rome, Alabama. Having worked with the early versions of these missiles, I could not help noting a certain family resemblance.

—O.H. Billmann

The Jargonauts

Okay, so the Teacup ride at the carnival makes you black out, and even wearing thick socks can trigger your fear of heights. Maybe you're not cut out to be an astronaut after all. But there's no reason you can't at least talk like one.

After all, astronauts don't spend much time in space anyway. Most of the time they're sitting in long meetings using words like "deploy" and "reconfigure" and looking wholesome. With a few simple lessons you'll be able to sling jargon with the most steely-eyed shuttle jockey.

Because slang is the key to mastering any language, I've compiled a simple English-to-Astronaut dictionary. For the sake of brevity (and because it's as far as I've gotten) we'll proceed only through the letter B:

ENGLISH	ASTRONAUT
average	nominal
bad	interesting
beautiful, spectacular	nominal!
bonehead	congressman
bummer	anomaly

Now let's use what we've just learned.

COMMANDER: That sure was a congressman move, Jim. You hit the wrong button and sent that weather satellite off toward Venus. We had a really nominal mission going, and now things are getting interesting.

YOU: Anomaly!

Much of space lingo is not actual words but acronyms. If astronauts didn't use acronyms, everything would take longer, and the time between shuttle flights would extend to three years instead of just seeming like it. By one calculation, astronauts save 31 percent of their valuable time by speaking in a way that only computers can recognize.

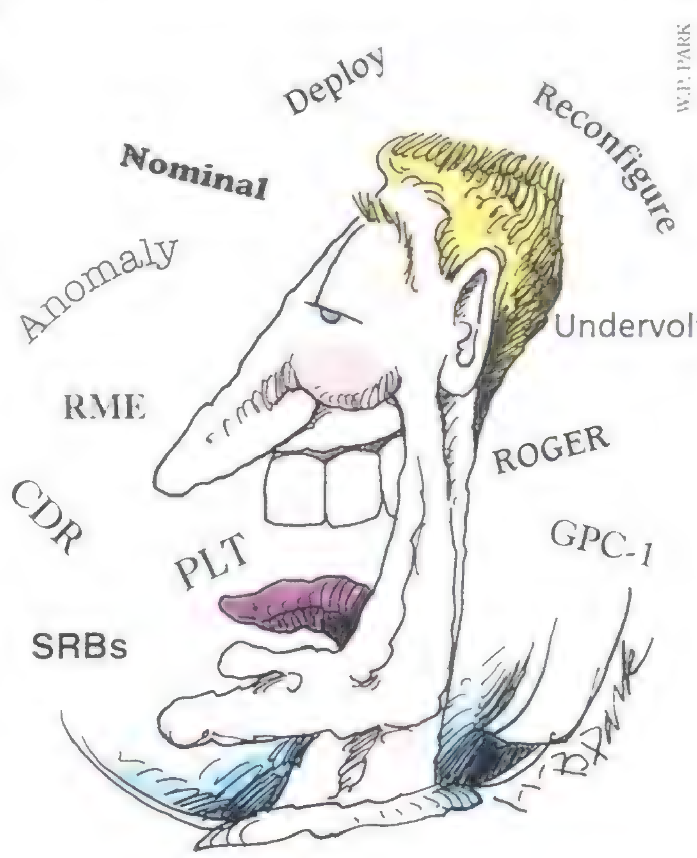
Think what would happen if shuttle commanders talked like you and me:

REGULAR PERSON: Uh, Jim, could you grab that little red thing over by the doohickey and bring it to me here in the room with all the screens and dials?

Compare this with the crisply efficient:

COMMANDER: RME, now!

Despite colorful names like "Ox" and



W.P. PARK

"Buzz," astronauts use more business-like handles in space. The designations for commander, pilot, and mission specialist that you see in NASA documents—CDR (pronounced "cedar"), PLT ("pult"), and MS-1 ("lackey")—aren't just for show. Astronauts actually use them in orbit, as in the following transcript:

MS-1: Pult, can you hear me? Pult? Pult? (Sound of static from saliva shorting out the microphone.)

You may wonder why mission specialists are given numbers like One, Two, and Three. It's because—and this is a secret known only to insiders like me—they're chosen exactly like contestants on "The Dating Game."

CHIEF ASTRONAUT: Mission Specialist Number Two, if you were a piece of raisin bread and I were cream cheese, how thickly would I be spread? (Wink at the selection committee.)

CONTESTANT: Uh…improper mixing of fuel in the SRBs?

CHIEF ASTRONAUT: Right!

Just as important as how you talk, of course, is what you talk about. It doesn't have to be all orbital mechanics either, as demonstrated in the following exchange.

REGULAR PERSON: Hey, have you seen that new movie about—

ASTRONAUT: No, actually, I've been up to my neck in sims. We had quite an interesting problem yesterday. Just after OMS-1 we lost GPC-1. I just went to circuit B when I saw the undervolt, and that solved 'er.

REGULAR PERSON: Uh, gotta run.

Music is another sure-fire way to show off your newfound knowledge. Here are some popular astronaut tunes you may want to throw on the CD player next time some ordinary boob comes over.

Oldies: "A Hard Day's Sleep Period"
Soul: "Papa's Got a Brand New Stowage Device"
Dixieland: "When the Saints Ingress"

Yes, with a little time—and $29.95 for the complete dictionary, sent to me care of this magazine—you too can be talking just like a PLT. Here's Lesson One, no charge to you.

CDR: Looks like we've got a go for the deploy, Bob-O!

YOU: Nominal!

—Tony Reichhardt

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The Last Piston Show

Who will bring home the trophies, the cash, the blown engines, and the broken airplanes? Air race fans make a yearly trip to the high desert to find out.

by Larry Lowe

Photographs by James Sugar/Black Star

Over the mountains of western Nevada, Laird Doctor bounces through the afternoon thermals in the front seat of his AT-6 World War II trainer. Easing out of a shallow left turn, he keeps a watchful eye on the six T-6s strung off his right wing. Doctor issues a stream of minor adjustments over the radio to nudge them into position: "Number five, you're too low, ease it up. Race 22, slow it down, slow it down. Fifty-six, tighten it up on the end, tighten it up." The stolid trainers lumber into line like so many fat, obedient geese. "Okay, gentlemen, we're over the ridge at 200 feet. Line abreast, line abreast. Final power increase coming on…now!" Doctor toggles a switch marked "smoke" and a thick white plume billows from the exhaust stack. Once satisfied that everyone is lined up on the steady dive toward the airport, he pulls up sharply and opens the starting

The propeller is still king at the Reno races, where piston engines are pushed to their limits—and sometimes beyond.

gate with the ritual words "Gentlemen, you have a race."

From their vantage at the first turn, the pylon judges watch the line of dots bunch up, then disappear below the horizon as the pilots rush to get as low as possible. Soon an unearthly growl rolls across the desert from the west. The gaggle of T-6s, much closer now, looms up out of the shimmering heat of the desert floor and thunders toward the first pylon.

As the T-6s near the number-one pylon, the blob bunches up again as they all seek the tightest course around the corner. The trainers hurtle past the pylon at 50 feet, flying a tight but fluid formation turn at over 250 mph. The crackle of supersonic shocks generated by the propeller tips rings in the ears. John Carstarphen and the three members of his judging team cluster at the base of the pylon, peering intently upward to make certain none of the aircraft cut inside the phone pole, and note the order of passing.

The National Championship Air Races at Reno is an anachronism in American aviation. It is a ritual of risky business from the wild youth of aviation preserved beyond its time. The three-ring circus is part demolition derby, part technology evaluation lab, and part aviation history museum. More than anything else, Reno is a celebration of the piston engine. And like monster truck jumping and mud wrestling, it is a uniquely American spectacle.

During their prime, in the 1930s, the Cleveland National Air Races were as much a part of the national sporting consciousness as the Indianapolis 500 is today. But that changed after World War II forced dramatic changes in aviation technology, pushing the piston engine to its limit, then replacing it with the turbojet. For a few years after the war there were attempts to race the big

Former astronaut Deke Slayton anchors his entry in the Formula One category of small but speedy homebuilts (right). Of Reno's four categories, the brutish Unlimited racers (below) draw the biggest crowds.

The constant cleaning and buffing is not purely for show. Even a few spots of dirt can nibble away precious airspeed.

piston fighters on small pre-war courses, but the results were disastrous. The Thompson Trophy race at Cleveland in 1949 was the last straw. During the second lap, a highly modified P-51 dove into a house, killing a housewife, her one-year-old child, and the pilot. Midget racers competed at various sites through 1960, but the big classics disappeared until 1964, when a Nevada rancher and hydroplane racer named Bill Stead organized the first modern air race at the Sky Ranch airfield outside Reno. Two years later the races moved to the old air base named for Stead's brother, where they have grown and prospered. Now 150,000 people show up each year to revel in the last big-time closed-course pylon air races.

Of the four race classes at Reno—Biplanes, Formula Ones, AT-6s, and Unlimiteds—the last category is the biggest draw. The Formula Ones and biplanes are slick homebuilts constructed around small general aviation engines, and the AT-6 trainers are all alike save paint scheme and speed mods. But the Unlimiteds are just what the name says. Aside from a rule stating that they must be propeller-driven and powered by piston engines, there are no holds barred. Two weeks of time trials and preliminaries culminate in the Unlimited Gold race on Sunday. The Gold race comes last, it is the fastest, and it offers the largest purse.

Compared with the genteel and efficient personal transport that is offered by promoters of general aviation, what goes on at Reno is definitely fringe activity. But hang around for a while and you get the sense that this is what flying is all about. This is flying in the raw, for the sheer exhilarating hell of it, with all the rewards and risks out on the table and not hiding under a veneer of respectability.

Reno is an event on the edge in more ways than one. Each year race organizers set aside part of the receipts to purchase a little more of the land under the race course, hoping eventually to buy it all before someone builds a subdivision and shuts them down. The Unlimiteds—some chopped and channeled and sporting monster engines, some looking as if they just flew in from active duty—are themselves an endangered species. And there is constant friction between the racers and the organizers over the prize money. "If you qualify fastest, win your heat races, and win the Gold, you might take home $40,000 or $50,000," says two-time winner Steve Hinton. "The Merlin [engine] in *Strega* alone would cost you twice that amount." There is talk among the racers of a boycott. But missing the annual gathering would be counterproductive at best. Any discord in the ranks may scare off what meager sponsorship money is available. As much as Reno needs the racers, the racers need Reno. No other venue has managed this much dependable racing, and until some place does, there's no place else to go.

As captain of the number-one pylon, John Carstarphen, calmly resplendent in his black and white striped referee's shirt, has a hammerlock on what he describes as the best seat in the house. The picture of judicial impartiality, he was pressed into service 15 years ago, back when there weren't enough pylon judges to go around. It seemed like a thankless task. The few volunteers spent the time between races

Like all fliers, air racers communicate with a unique language: Bill Destefani flies the course with his hands (far left), while a T-6 crew leaves a cryptic message for its pilot (left).

bouncing across the desert from one course to another. Now that interest in the races has escalated, there is a waiting list 30 deep for Carstarphen's job.

The herd of T-6s thunders down the back of the course like stampeding elephants, again disappearing into the desert floor, as the race degenerates into a treacherous parade of hurtling metal and sonic assault. "We could call in the results now and save these guys the gas," Carstarphen notes with a wry grin. It seldom fails, he says, that the order in which they pass the first pylon is the order in which they finish at the home pylon. Ten minutes and five laps later, Carstarphen's prediction is vindicated. The order of finish is identical to the order of the first lap.

Reno is aviation's last bastion of organized recklessness. Here a pilot can literally take his life into his own hands and as close to the desert floor as he or she dares. For the AT-6 racers, low flying seems a point of honor. The racers explain their daring as an attempt to gain competitive advantage rather than an expression of machismo. The lower you fly, the easier it is to maintain the tightest course around the 40-foot pylons, and flying the tightest course will force your competitors outside or above you, requiring them to expend more energy to pass you. And since the T-6 class is the equivalent of stock car racing—everyone starts with the same basic airframe and a 600-horsepower radial engine—winning usually boils down to who gets to the number-one pylon at pylon level in the tightest position. But as Unlimited racer Rick Brickert observes, "There is no way to set a new record for low flying. The best you can hope for is a tie for first place." This year Jim Mott ties the record, flying his T-6 into the ground in a frantic attempt to qualify. The airplane is demolished, but Mott walks away, hoping to race again next year.

Unlimited-class air racing is slowly dying. Every year a few more great old fighters are missing, a few more familiar faces are gone. This year several Hawker Sea Furies and two P-51 Mustangs are out of the running, as is a Chance-Vought Corsair, whose pilot ended up in a tree after bailing out at the last minute. Out on the pylons, talk is of what will happen on the Day They Break the Last Merlin, the legendary Rolls-Royce engine that powered the Spitfire and the Mustang. Ironically, in the very act of preserving the essence of the kind of aviation that the Merlin represents, the racers are helping to condemn it to extinction.

A lone Curtiss P-40N sits in the center of the Unlimited pit, a pickpocket in league with bank robbers. With generic olive drab and gray paint and star and bar, it is literally a museum piece, one of the few remaining specimens of the thousands of Warhawks that flew in World War II. Once a year the owners take it out of the Warhawk Air Museum in Caldwell, Idaho, bring it to Reno, and run it in the Bronze race. They lose, of course, and when the airshow season is over they put it back in the museum alongside an older, rarer P-40E and a P-51B. Perhaps only two dozen P-40s can still fly, but curator Sue Paul thinks the rewards of showing the audience a vintage U.S. fighter are worth the risk.

The fate of the sport is uncertain. A new source of Unlimiteds is needed, for one thing. The old Lear 23 corporate jets are close to the end of their service lives, and some will eventually be scavenged for parts. Perhaps you could build an experimental class around the high-speed wings, add a new fuselage and a piston engine. One loosely formed concept calls for racing older corporate-class turboprops, like the Mitsubishi MU-2, as a class. You'd still have racing, but most agree that without the old big-bore piston engines and the classic forms they propel, you wouldn't have much. Says Bill Rheinschild, who is flying his P-51 this year, "If we quit racing Mustangs and Bearcats, we'll quit racing."

Carstarphen's claim to the best seat in the house is arguable. To understand Reno, you have to hang out with the rowdies in Section Three of the grandstand. You need to walk out of the pits, with their intimate array of racers and crew, past the ritzy Checkered Flag Club, where members in monogrammed jackets munch on hors d'oeuvres, past the reserved seats, the exclusive press and VIP tents. Walk past the box seats to the general admission grandstand. There you will find the noisy, raucous, thrill-crazed essence of Reno: a vibrant orange blur in Section Three.

It began in 1984, when repeat visitors started recognizing one another. Section Three soon evolved into a full-fledged fraternity. They even have a scrapbook. Now the orange T-shirts and scorecards that are brandished for every act, every race, and innocent passersby are a part of the show, along

with a cacophony of air horns and bullhorns. "Ain't that some kind of flying?" the announcer asks. "Oh, *yeaaahhh*!" comes Section Three's reply.

The people in the orange T-shirts come from most walks of life, from across the country; all they have in common is the annual pageant at Section Three, general admission grandstand, National Championship Air Races. Admission to this club requires only a love of hot flying and big engines and a commitment to come to Reno every September. Elliott Cross sums up the draw: "A lot of people know that they're going to do this every year, forever."

Section Three and the pilots have formed a mutual admiration society. Most of the airshow and race pilots make their way to the stands to be

Reno fans return year after year for the passing parade, which usually includes a six-second race between a fire-breathing, jet-powered dragster and an airshow performer's airplane.

mobbed by orange fans, whose T-shirts are covered with pilots' autographs. The only performer who doesn't garner an appreciative burst of waving grade cards is an insipid would-be comedian with a J-3 Cub, a dog, and some ducks. This is not why you come to Reno. Section Three is chafing for some real action.

They soon get it. Late in the afternoon a Navy pilot works out with his F-14, booming around the sky with those big engines in burner half the time and the noise aimed at the grandstands as often as possible. After landing, the Tomcat taxis past the main grandstand, pivots to point at the seats in Section Three, and runs up the engines with the brakes locked, compressing the nose gear strut to take a bow. Then the

pilot holds up an orange T-shirt. Section Three leaps to its feet in reply, a frenzy of waving grade cards and blaring air horns. The moment is even better than a Sikorsky Skycrane dropping a school bus on the airport's infield from a mile up.

But Section Three's all-time favorites are Lyle Shelton and *Rare Bear.* Brute force is the hallmark of this Grumman F8F-2 Bearcat. "Short, fat airplanes aren't supposed to go this fast," Shelton says. The soft-spoken pilot does not fit the expected image—something along the lines of Hulk Hogan driving a Monster Truck. Shelton seems uncomfortable in the role of celebrity, but he is too nice to say so. Saturday evening, standing atop the tractor-trailer that is *Rare Bear*'s mobile support facility, he explains his involvement with air racing. He was here—by coincidence—

The Mustang lookalike Tsunami *competed for the last time at Reno. The air race veteran crashed 10 days later.*

Burt Rutan's Pond Racer, designed to outpace and therefore preserve the old fighters, made a troubled debut last fall.

back when the Reno races started, and something grabbed him during that first race. Nearly 30 years later the five-time winner is the odds-on favorite to win again tomorrow. So what's the point of the exercise?

"Well, to win," Shelton says. "To win. In any sport or endeavor you like to win, to do your best, beat the other guys fair and square." Shelton could be the Gary Cooper of air racing, taciturn and forthright, a straight shooter with the biggest gun in town. "I've heard that everybody ought to have a little bit of danger in their lives," he says. "I don't know if it builds character but maybe it keeps a little character. I think it does something for the human psyche to get on the edge now and then, one way or the other."

The 3,350 cubic inches shoehorned under the Bearcat's cowling generate enough horsepower, well over 4,000, to pull Shelton and *Rare Bear* right up to the edge of the performance envelope. Last year the pair set a new race record, 468 mph. "Shelton is up near the limit," says Bill Rheinschild. "That wing was never meant to go that fast, not like a P-51. Someday it may come apart on him."

If Shelton is the Road Runner, blasting a trail of dust across the high desert floor, Bill "Tiger" Destefani is the conniving Wile E. Coyote, secretly assembling his Acme Rocket-Powered Roller Skates and brandishing his certified Bear-proof capture net. But Destefani just can't catch the wicked fast Bearcat.

A cotton farmer from Bakersfield, California, Destefani exudes country cunning. Pulling up a 55-gallon drum as a seat, he warms to the task of explaining his strategy. It is a tale of telemetry and tactics. His team keeps him apprised of the race situation by a two-word code radioed once per lap. The engine is wound so tight, he says, that pulling the throttle back too quickly will destroy it. Bottom line? He's got the stuff to beat Shelton. "Let me tell you something," he says, leaning forward, eyes glistening. Referring to Shelton's one-lap closed-course record, only hours old, he says, "Four seventy-seven? That's baby shit. Wait until tomorrow." The basis for Destefani's optimism is a red and white P-51 Mustang, *Strega,* Italian for "witch." A stuffed witch on a broomstick adorns the top of the tarp covering *Strega*'s pit. The stage is set for tomorrow's shootout. Racers, pit crews, and spectators retire to party away the remaining hours.

Midnight. A walk along the ramp. A gleam shifts in the darkness, then reveals itself as the silver and blue P-51D *Platinum Plus.* It's there and yet it's not. The Mustang has been hand

Perestroika, *a Yak-11 from Klamath Falls, Oregon, placed a respectable fourth in the final race (right).*

polished with cornstarch for hours until the finish is so fine it reflects the dark. You can't actually see the whole airplane; its form is defined by curved reflections of a thousand tiny pinpoints of starlight.

A resonant howl drifts down from further up the pit lanes. An engine is running in the dead of night. Out on the ramp, something fantastic stands alone. It's the Pond Racer, bathed in a pool of light from portable spots, all flowing white curves and engine pods. The four stubby blades on the right engine form a translucent disk. The crew stands transfixed. One holds a fire extinguisher.

The world's fastest Bearcat, the beloved Rare Bear, *returned in 1991 to set yet another blistering record pace.*

The group stares at what may be the future of air racing. The exotic all-composite twin-boom design is yet another radical departure by Burt Rutan, this one built to the specifications of millionaire airplane collector Bob Pond. The highest point on the Pond won't reach a P-51 wingtip. The big guys could run over it on a taxiway. If it can win the Unlimited, it will contribute immeasurably to the preservation of aviation's piston-power heritage. The day a modern design like this wins the Gold race, all the World War II contenders will finally be rendered obsolete.

The newborn is still teething. The Pond Racer wails, straining at the cord that binds the right tail boom to the ramp. Few spectators knew that the airplane flew today's qualifying race with the right engine at idle. The Rutan crew must find out why before morning. As the rpm slides up and down, subtle changes in the sound of the distressed engine provide clues. Sometimes it runs smoothly, sounding like a massive dynamo. At other times, a sporadic chuttering undertone is accompanied by belches of blue flame from the exhaust stacks. For the first time in the history of air racing, a malfunction in the engine sounds like a software problem.

Test complete, data from the run stored in computer memory, the crew shuts down the engine and attaches fans to the nacelle to flush out the heat. Crew chief Bruce Evans isn't talking. Nor is anyone else. All discussion of the Pond Racer must come from the front office. It is a tense and frustrated crew that is trying to nurse the airplane through its first public performance. A

Rare Bear*'s pilot, six-time champion Lyle Shelton, is congenial but a little shy among well-wishers (above). Other racers—and fans—are less reserved (right).*

longtime Rutan supporter is quick to pronounce its appearance Reno's "story of the year." Air race veterans privately wonder if the machine will last the week. Reno doesn't seem a likely site to run a methodical test program.

Gold Sunday. Late in the afternoon the fans in Section Three are on their feet as Steve Hinton, flying a crimson Lockheed T-33 pace jet, leads the Unlimiteds down the chute for the big race. For the next 10 minutes, the world's fastest propeller-driven airplanes roar around the 9.128-mile course eight times in loose trail. Midway through the race,

Strega edges slightly closer to *Rare Bear.* The mere prospect of a position change drives the crowd to fever pitch. It never happens.

It is no picnic in the cockpit of *Rare Bear,* despite the apparent ease with which Shelton maintains the lead. It is not just the periodic onset of G forces in the wrenching pylon turns. The mismatch of propeller to airframe demands constant special handling. The stubby prop blades set up such a gyroscopic effect that every time Shelton pulls in or out of a turn, which is roughly half the time spent in the race, the nose wants to slew around. "It's the most physically demanding thing I've ever done," Shelton says later. "My legs, upper thighs are tired from working the rudders. It's a heavy prop, and that gives me a significant torque. When I pull G the nose wants to swing to the right, then as the G eases off the nose wants to swing back to the left."

Strega spends the race nipping at *Rare Bear*'s heels. Skip Holm in *Tsunami,* a homebuilt Mustang lookalike, chases the two around the course, hoping to pounce into the lead in the event either of them blows an engine. (This will be *Tsunami*'s last race. On the way home both the airplane and its owner-builder, John Sandberg, are lost when a flap actuator breaks and the airplane corkscrews into the ground on approach to the Pierre, South Dakota airport.)

The Pond Racer sits out the day in a hangar. While the crew had focused its attention all week on a series of problems with the right engine, it was the left that surprised pilot Rick Brickert by throwing five rods and bursting into flames as he was joining the formation for the Silver race's start. This baptism of fire concluded the craft's first competitive appearance. (Months later, Pond, Brickert, and pilot Dick Rutan are all upbeat. This was the Pond's rookie season. They came just to see how it would do in race conditions. They learned a lot. There is pair of bigger engines waiting back in Chino. They know they have to shield the wiring. There will be other years....)

Destefani was right. His average speed on Sunday is faster than Shelton's Saturday one-lap record of 477 mph. But it is not fast enough to win. Shelton's average race speed of 481.618 is the new Gold race record. *Strega* takes second with 478.68, and *Tsunami* is a close third at 478.14. After a year of preparation and weeks of anticipation, the thing is over almost as soon as it starts. An airplane covering 73 miles at nearly 500 mph behind a 4,000-horsepower engine and a propeller is a brief but marvelous thing to behold.

By early evening the grandstands are empty. Shelton, now a six-time champion, has shown up at the press conference, said a few words of thanks to his crew and sponsor, kissed the air race queen, and taken home $51,403 in prizes. It is a token compared to the cost of running *Rare Bear.*

Traffic out of the airport is thinning. *The Healer,* a Mustang, is parked near the pit entrance. The airplane is tired. A torrent of exhaust, pressed back against the body of the airplane by the slipstream, has burnt its mark. Iridescent bluing of heat on the polished metal blends with the reflections of the deepening pink sky, giving the Mustang a fire-opal coat. The main gear inner doors slowly ease down as hydraulic pressure ebbs.

A couple approaches, almost reverent. Twenty-dollar pit-pass bands on their wrists mark them as serious enthusiasts. They stand at an angle off the nose where every definitive aspect of a Mustang looks best. They are out of film, so they just stand, marveling, absorbing the moment.

They met by chance. They both liked airplanes. One of their first dates was a Reno air race. When it was over, she said, "If we're still together at this time next year, can we come back?" That was 12 years ago, and they haven't missed a Reno since.

Pepsi's 1929 Travel Air got in a little advertising between heats (above), while Tsunami *pilot Skip Holm calculated his strategy (right).*

At first, the large rocket seems to make no sound. Only light. So much light, such an elemental brilliance, that the mile between me and the launch pad seems just a stone's throw.

The rocket, a long, thin Black Brant IX perched atop a Terrier booster, leaps into the night air like a flung javelin. There is none of the "We have ignition…liftoff…the orbiter has cleared the pad" stateliness of a space shuttle launch. The Brant is *outta* there, sniffing stratosphere by the time its crackling roar gallops across the mesquite and cholla of New Mexico's White Sands Missile Range.

A small crowd watches from the launch complex near a blockhouse, a chunky military building with "NAVY" in big letters across its roof. This group, however, is about as government-issue as a Windham Hill concert. There are young men and women with the scruffy look of grad students after an all-nighter—which is exactly what they are. There are children, mothers, wives, some of whom are chanting,"Daddy-daddy he's our man! If he can't do it no one can!"

For this is a research rocket, not a missile, and upon its plume of fire and approximately $1 million in NASA and University of Colorado grant money ride the hopes of one 26-year-old graduate astrophysics student. He has spent the last three and a half years designing, building, tuning, and stroking the 12-foot-long payload that the Brant is lofting into space. He is Daddydaddy to his wife and two-year-old son. He is Erik to his friends. He is "Gradual Student Wilkinson," according to the legend he has Magic-Markered on his hardhat. He is my nephew.

I've known Erik since he was a baby, the firstborn of my architect brother Kirk. After turning his back on a Harvard Design School degree and quitting a prestigious Cambridge firm, Kirk took his second wife and two young children and moved to rural New Hampshire, where he became a carpenter and designer. But for the odd coincidence that Erik eventually graduated from the Concord, New Hampshire school where the Challenger Seven's

by Stephan Wilkinson

My nephew, the rocket scientist.

ERIK'S ROC

PAUL CHESLEY ©

With $1 million in grant money and more than three years of labor involved, rocketry is serious business for graduate student Erik Wilkinson (left). Though the stakes are high, there's room for humor, as the "Far Side" cartoon on a University of Colorado wall indicates (below).

Christa McAuliffe was teaching—"I'd seen her around the halls, but I never took any courses from her," he recalls—Erik grew up about as far from White Sands and rocketry as anyone could.

Yet always there was that shop full of power tools, and a father with skilled hands and a trained, inventive mind. And a mother whose genes bore creativity, dexterity, and imagination as well, for Erik is the grandson of that favorite of crossword puzzle writers, architect Eero Saarinen.

"As a kid, I was constantly making things of wood and working with Dad," Erik reminisces. "Then I became a set designer and builder for the drama club at Concord High School, and I was always playing with motorcycles, model airplanes.... We used to go to Cape Cod and fly control-line models on Grandpa's tennis court. You crashed one, I remember, and Grandpa was annoyed that we got gasoline all over the court." I'd forgotten.

For a time Erik and his younger brother Mark dabbled with motorbikes, sometimes fabricating their own replacement parts, until the expense sent them back to the unpowered variety. And it turns out there were a few rockets even then. Erik bought a solid-propellant motor from a hobby shop, then built a body for it by wrapping packing tape around a fat dowel. He didn't realize until it was set up for launch, on a big boulder outside their New Hampshire barn, that it would need some kind of remote igniter. "*'So how are we gonna fire this?'* I thought. I wasn't a rich kid with an Estes push-button launcher, so Mark and I took an old model train transformer we found in the barn, hooked it up to an extension cord, and zipped the handle full forward. It worked."

Why didn't he just use a dry cell battery and two wires? "Far too simple, Steve," Erik laughs. "Not technical enough."

Model rocket building is, not surprisingly, a common denominator among people who play with the full-size versions as adults. "We launched Estes models, yeah, but what we really liked were the Flight Systems kits," admits James Green, the 31-year-old principal investigator for Erik's payload. "Estes motors went from size A up to D. Flight Systems' went on to F. You could build some big mothers with those."

Jim Green is what those who know him lovingly call a geek. His hair is usually askew, tumbling over his forehead, and the beltline of his blue jeans sinks lower and lower as his enthusiasm rises. And his enthusiasm for rockets and astrophysics is enormous. It will be Green, not grad students, who stays up until 5 a.m. helping Erik calibrate the payload and crate it for transport to White Sands. Green is considerably shorter and somewhat rounder than Erik's beanpole six-foot-three; and together, as they often are, they are rocketeering's Mutt and Jeff.

At a lunch table gathering of the students and engineers of the payload building team, Green conducts an impromptu poll. "All right," he says, "Who just built their models and launched 'em, and who took the time to paint 'em up?" Erik is the only person to admit he bothered to decorate his rockets. A knowing laugh goes up from the build-and-blast crowd, for Erik has already acquired a reputation as a compulsive, a payload builder who leaves no component untested, no doubt unresolved. He is an experimenter who sweats the details.

Through most of high school, Erik intended to become a marine biologist, for his earliest career plans sprouted amid the tidepools, ponds, and wetlands of Cape Cod, where he spent childhood summers. "But toward the end of high school, I literally woke up one day and said, 'I'll do physics!' " he recalls. "That's as close as I've ever come to having destiny twist my head around." Not only destiny but a much-thumbed Time/Life series, *The Universe*, and an enthusiastic young substitute physics teacher at Concord High. "She made that course so much fun," Erik says today.

"Was Erik brilliant in school?" his

KET

PAUL CHESLEY ©

mother, Susan Saarinen, muses. "No, Erik is not a 'brilliant child.'" Erik had to overcome dyslexia in his primary-school years before developing a lasting enthusiasm for learning. "He is an extremely hard worker," says his mother. "He has impeccable study habits. He will not leave a question unanswered. I guess he was particularly unusual in high school only because he was...so conscientious."

Today, some of his relatives kid about Erik being the Rocket Scientist. "I don't mind," he laughs, "because I'm not as bright as people therefore assume I am. But I don't tell them otherwise."

An academic science career wasn't a popular decision with his father. Money was tight, and he wanted Erik to enlist in the military. "The Navy wanted me for nuclear submarines, since I scored particularly well in that part of the testing, and the Army said I was perfect for chemical warfare," says Erik. "I said 'Yeah, right' and went to the University of New Hampshire instead. Dad said I'd piss all the money away—that's exactly how he put it—so I came home with a 3.72 average and rubbed his face in it."

"Oh, yeah, it was one of my all-time worst moves," my brother Kirk admits today. "As it turned out, we were able to manage the college finances, but [the military] seemed like such a good deal—'See the world' and all that. I was a jerk, I gotta say. I was struggling myself and wasn't particularly focusing on what he was really capable of."

"Going to a college where he was told in advance he was going to fail was one of his greatest motivations," says Erik's wife Susan, whom he'd met at UNH. "It could have been disastrous, but to him, it was a goad."

There are three kinds of astrophysicists: theorists, observationalists, and experimentalists. Theorists conceptualize, mull over cosmology, and teach. Observationalists crunch numbers, converting raw data into meaning. Sometimes they utilize telescopes, satellites, and sensors, sometimes they simply accept the numbers that such tools produce, but in any case they are not hardware-oriented.

It's the experimentalists who get their hands dirty. They design and build telescopes, satellites, and other space payloads. They wire, fabricate, mill, grind, and polish. They carry toolboxes full of socket wrenches and needlenose pliers. They're more likely to be found amid the desolation of Australia's Woomera Rocket Range or NASA's icebound facilities at Poker Flats, Alaska, than in the groves of academe.

James Green, the principal investigator for the G-191-B2B observation mission, consults with Erik (above).

Top: Even a scientist under the pressure of graduate school can kick up his heels on occasion, as Erik does with his wife and son (at right) and friends at a mall near the university.

And they have a good time. "Yeah, launching a rocket is fun," Jim Green admits. "They go boom, they light up the night sky, and they're neat. When we want to entice grad students to come work for us, we send them to White Sands to see a launch. It works every time."

Erik is an experimentalist. "My brother Mark once said of me that all my life I've been building things, so what do I do as an adult but find the most complex, difficult thing I can possibly build—a rocket payload."

Compared with an F-16, Erik's star-observing payload is not terribly complex. It's only about as sophisticated as a used Learjet. And worth about as much, when you factor in the cost of launching it. The optics alone are worth $350,000. The 27-pound spectrograph frame was hogged out of a $1,000, two-hundred-pound block of pure, forged aluminum at a cost of $6,200 in machine-shop time. Erik tosses around such numbers as "blowing $30,000 on machining" and $65,000 for a diffraction grating. "Heaven forbid I should ever drop it," he says as he points to the grating, which sits on a workbench in his University of Colorado lab under a Rubbermaid Servin' Saver plastic cover.

Designing a good astronomy payload for a rocket is an enormously sophisticated packaging job (see "The Payload," opposite). An entire observatory must be fitted into an aluminum canister about the size of a fat torpedo. Sections of the payload interior must be able to withstand a near-vacuum equivalent to one-billionth of an atmosphere. It must be inflexibly mounted and robustly wired to withstand the shock of its semi-controlled parachute landing at the conclusion of the mission. A good payload is used again and again.

Erik describes how one payload was ruined by a loose washer in a spectrograph can. "Under considerable accel-

eration at launch, it embedded itself in the detector face," Erik says. "They'd also failed to mount the spectrograph securely enough, so the whole instrument broke loose.

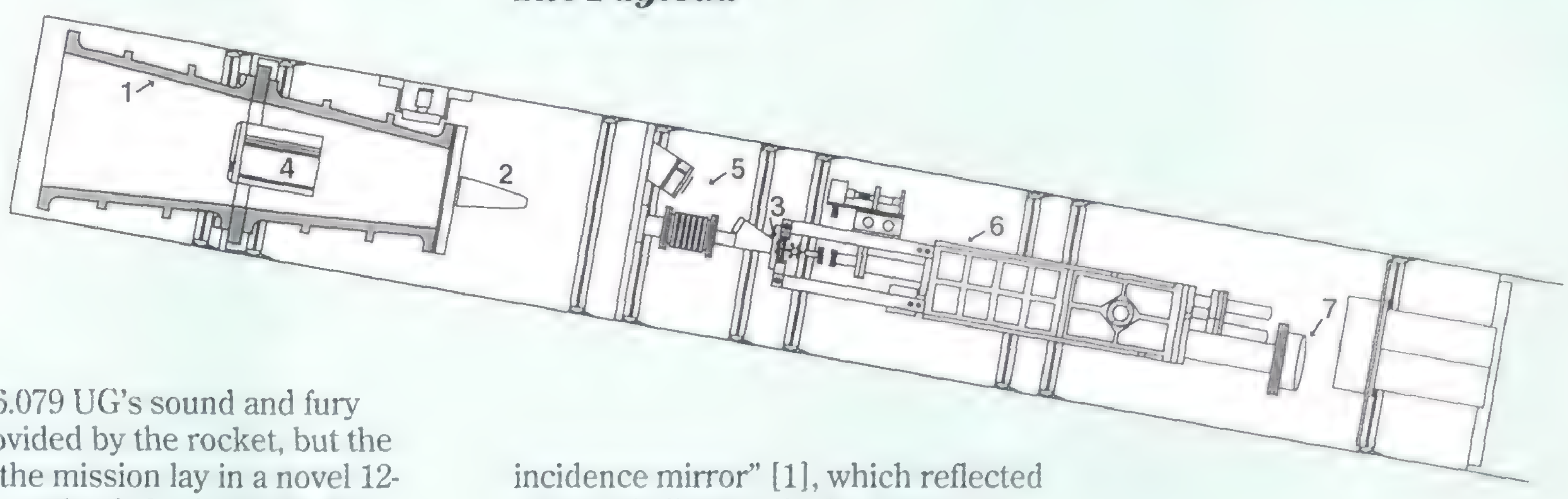
"Grad students are each expected to make one $20,000 mistake," Erik says, "ruin a detector or touch a telescope mirror, say—but you learn never to repeat a mistake." As he says this, he is casually running cryogenic pumps and hooking up electrical cables to a huge, submarine-shaped test chamber. Elsewhere in the astrophysics building, other young men and women are running blocks of equally daunting equipment.

RICHARD NOWITZ

Erik's work took him to NASA's Wallops Flight Facility in Virginia. Between bouts of integrating and testing the payload, he found time to read on Chincoteague Island.

Erik is also learning about the politics of science and the jealousies of academia—a necessary and inevitable part of any graduate student's education. "There's really no difference between politics, business, and science," he says, "because all three ultimately

The Payload



Flight 36.079 UG's sound and fury were provided by the rocket, but the heart of the mission lay in a novel 12-foot-long payload. Designed by Erik Wilkinson, it would attempt to measure extreme-ultraviolet radiation from a white dwarf star, G191-B2B.

Gosh, whatever for? "It shows us how much helium is in the photosphere of that star," Erik patiently explains. "That doesn't tell us much by itself, until you go and do a lot of theoretical work. Theory tells us there shouldn't be any helium there," yet observations at longer wavelengths have hinted that the gas may be present. "No one's ever observed this star in this wavelength before, so we think there's helium there, but we don't know. Whatever we see will be new—will be a surprise.

"By finding out how much helium there is, we can find out where this star came from, how it evolved, what kind of star turned into this white dwarf, what kind of physical process is going on there. It'll show us whether the current models of white dwarf structure and energy processes are right or wrong, and will force people to come up with better models."

Erik's payload consisted of a megaphone-shaped "grazing-incidence mirror" [1], which reflected at very shallow angle the extreme-ultraviolet light from the star—energy so close to X-ray frequencies that it would have been absorbed and lost in a head-on collision with a normal-incidence telescope mirror. The light was further concentrated by a similarly tapered secondary mirror [2], and it converged to a point at the prime aperture [3].

The barrel of the main mirror contained a star tracker [4], which, though not smart enough to find little G191-B2B, could find the light of a particularly bright star such as Capella and use it (plus triangulation from a second bright star) to initialize the attitude control system.

Once the star tracker acquired Capella, the ACS shifted the payload to point at the correct general starfield. Now Erik was able to see his target and manually steer the payload, via a computer uplink with the ACS and its nitrogen gas jets, to aim directly at it. An aperture monitor [5] scanning the prime aperture provided him with an exact real-time picture of the starfield.

The extreme-ultraviolet energy then entered the spectrograph [6], where it diverged and was reconverged by a toroidal mirror. Inside the spectrograph was also a diffraction grating—"a very expensive piece of scratched aluminum, essentially," Erik says—"that, like an optical prism separating white light into its constituent colors, can do the same thing for any wavelength of light. The grating we're using separates the extreme-ultraviolet light into its 'colors,' and we use a detector [7] to see them." When the light is diffracted by the grating, photons are directed to different positions on the detector depending on their energy. "By counting the number of photons that hit a specific location on the detector," Erik says, "we know how much of a single wavelength is coming from the star. What we were doing was saying, 'Here's a photon, it goes in this bin, and here's one that goes into that bin.' And when we're all done, we see how many photons are in each bin."

Hey, it shouldn't take a rocket scientist to figure that out, right?

get down to people, and people all have the same faults. There's nothing about science that makes it particularly pure or pristine."

Plagiarism by prestigious university researchers, government funds that were spent on a yacht, pork barrel battles over the Superconducting Supercollider, medical researchers scuffling to protect their AIDS-cure turf..."Oh, yeah, the world is learning that scientists are mean, nasty, and rotten—just like the rest of the world," Erik says. "You're also working with a lot of extreme egos, scientists who think they're solving the mysteries of the universe, that sort of thing."

"I don't think Erik will ever go into academia," his wife Susan says. "The egotism bothers him—

PAUL CHESLEY

people pounding themselves on the chest and puffing themselves up all the time. And I don't think he'll go to work for NASA. The bureaucracy would frustrate him. I think he'll go into the aerospace industry."

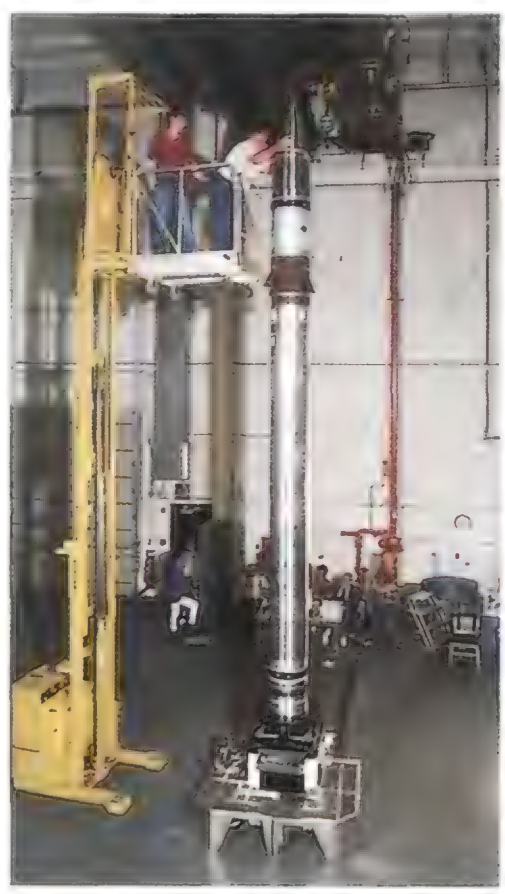
CHAD SLATTERY

"Scientists should go into industry," Erik says. "They don't all have to fight for grants. Distribute the knowledge some."

"Damn it, I'm not going to let a dozen doughnuts ruin this launch," Erik suddenly says. It is only hours until T minus zero, but Erik quits fussing with a computer problem and strides out of the building to his car.

"You have to appease the Doughnut God," he says. "It's very important. Twice when the doughnuts have been forgotten, the launch has either failed or been scrubbed. It's the job of the person in charge of the launch—the grad student, typically—to get those doughnuts."

Trays of doughnuts have already been delivered to the launch blockhouse, where Navy and contractor personnel are killing time until their brief work begins. More trays are being pawed over by technicians in building N200, where the payload was given its penultimate checks and fine-tuning. But Erik has suddenly realized that he has forgotten to take the last dozen doughnuts to the small crew in the VAB—the vehicle assembly building. It is from here that the telemetry from the rocket will be handled.



RICHARD NOWITZ

The Doughnut God is an important tradition, for there is no room at a sounding rocket launch for pretentiousness. Caution, dedication, care, hard work, and even a little hysteria all have their places, but humbug is not allowed. (When a rival graduate school group made the mistake of leaving its rather pompously personalized hardhats behind at the payload checkout lab at White Sands, Erik's group epoxied soft drink cans to the crowns.) The rocketeers have freely adorned the Black Brant with graffiti. "Bob's First Bird" is scrawled in big letters along the length of the booster, in honor of 24-year-old Robert Spagnuolo, who has been made NASA program manager of a launch for the first time. Erik, beset by anomalies, equipment failures, and crises right down to the wire, has adorned the canard fins with the legend "She fought us all the way!"

At the other end of the rocket, each guide fin is signed—one says "Katrina Bergman's," another simply "Leilani." A Navy seaman has offered to retrieve them for the autographers after the glowing booster falls back to earth. Even Erik's little boy, Kirk, gets in his licks, christening the booster with an enthusiastic two-year-old's ball-of-yarn signature.

And near the telescope section of the payload, electronics technician Stuart MacKellar has written "Objects in mirror are closer than they appear."

Erik and fellow graduate student Ron Wurtz enjoy hiking through the beautiful Colorado terrain (above).

At Wallops, Erik and technician Harold Bruce make some final adjustments to the payload (right).

After arriving at White Sands, the payload was mounted on a launch rail, attached to its booster and sustainer motors, then festooned with "umbies"—the umbilical cables that provide ground power until the rocket tears itself loose. All was then ready for liftoff (top).

No sound. Only light. The rocket is gone, and the roar has yet to reach us. For one nervous but intensely focused about-to-be astrophysicist, it's payback time. Now, in an ill-lit concrete block control room full of surprisingly archaic equipment, Erik must, in an absolute maximum of two and a half minutes, find and identify star G191-B2B, steer his telescope exactly at it, and pray that data begins to stream back.

The primary screen, one of several that Erik watches as a crucial payload door opens 65 miles above our heads, is a baffling dazzle of light, sparkling with the energy of stray photons. Somehow he sees real stars through the babble. "Okay. Okay. There it is. Yes. C'mon...c'mon. Yes." Erik superimposes the crosshairs on G191-B2B and punches the lock button. The screens go dead, and the same shout jumps from every throat: *"We've lost the displays!"* A technician has pulled a jack in order to check a circuit. He quickly reinserts it and the screens come alive again.

But there is no data. The crucial "science" screen is blank. Wrong star? Erik moves the crosshairs to a star he'd dismissed as G191-B2B's binary companion, -B2A. The clock is running. What if the payload is misoriented 180 degrees from what he'd assumed, and "up" is really down? Still no data. Erik has 250 seconds before the payload reaches its 158-mile-high apogee, arcs over, and plunges back into the atmosphere. If a mission doesn't achieve a minimum of 100 seconds of data acquisition, it is rated a failure.

Erik immediately decides he was right the first time but that the telescope must have been mis-aimed. He goes back to the first star and aims as precisely as he can. Far above us, tiny nitrogen gas jets snort soundlessly as the payload's attitude control system heeds Erik's telemetered commands.

Yes! The science screen comes alive with an arcing trace, a comet of micro-information tumbling across it. There is considerably less data than Erik had predicted—25 photon counts per second rather than the hoped-for 300—but it is not a disappointment, for there is almost no background noise. Every bit of data is clean, usable, meaningful.

It is over in three minutes. Three and a half years of work. Three minutes of intensity as white-hot as the Brant's exhaust. And now a year of paperwork, theory, and thesis writing. "From here on out, it's a matter of analyzing the data," Erik muses back in Boulder. "I'll do that until I get sick of it...and then I'll probably wish I was back down in the lab again, building a payload."

Celebration time! Champagne corks fly as Erik, holding son Kirk, toasts the launch of Flight 36.079 UG.

NASA's Sounding Rockets

Since 1959, NASA's sounding rocket program has been providing scientists (and, occasionally, commercial ventures) with cheap albeit brief lob shots into space. Cheap is relative, of course: by the time an experiment is built, rocket motors and guidance systems added, scientists and students flown to NASA committee meetings, missile range rented, support personnel paid, and Army recovery helicopters hired, $1 million will go up in spectacular smoke—$4,000 a second to "collect photons," as astronomers deprecatingly describe their jobs.

Yet the beauty of a sounding rocket is that nothing aboard one needs to be "man-rated"—so totally proven and extensively tested that its safety is virtually guaranteed, as it would be were it aboard a shuttle. "When you do a satellite project everything is supposed to be perfect, and it would make an experiment like mine uneconomical," Erik explains. "A sounding rocket is a high-risk, low-cost operation. When it works, hey, great. If not, that's part of this business."

"If you can avoid all the safety requirements, you can afford to fail," says Webster Cash, a University of Colorado astrophysicist and Erik's faculty advisor. "Okay, our failure rate goes from five percent to 15, but if at the same time you cut your cost by a factor of three, you win big. The sounding rocket program is still done in the old tradition of those 15 years when NASA was really something special, doing things they'd never be allowed to do today. They can no longer even afford their own programs."

"The really neat thing about a rocket [experiment] is that one person can understand and do the whole thing," says James Green, the principal investigator on Erik's experiment. "You couldn't possibly do that with the shuttle. With sounding rockets, a grad student can get his or her hands on every aspect, from design to fabrication to the electronics. NASA would continue to launch them even if the only thing they did was train grad students. But we also want to do good science, not just technical exercises. We want to be *clever.*"

Good science also helps guarantee the grant money that makes future launches possible. "We have to keep launching," explains Dave Hofmockel, the payload's electrical engineer. "It's competitive. We're hustling to get grants, and a lot of our success depends on the work already done. There are a lot of other institutions competing for these same grants."

Perhaps unintentionally, Erik uses a particularly appropriate phrase while discussing his payload with Webster Cash. "Even if it does work perfectly, there's the data that comes back," Cash says. "Will it be really useful, exciting? Will we see helium? Will there be real features there?"

"I'm banking on it," Erik says. Cash guffaws and says, "We're both banking on it."

Painting with Numbers

Even if a picture is worth a million bits, why wait a hundred years to see it?

by George C. Larson

If people were a little more patient, we wouldn't need supercomputers. After all, if a calculation can be done by hand in, say, a couple of hundred man-years, all you have to do is hire a couple of hundred people and wait a year. Or you could avoid long, complicated math altogether and stick to the simple stuff, like balancing your checkbook.

But life isn't simple, and if we want to understand the complex natural processes behind sciences like aerodynamics and meteorology, we have to produce system models that duplicate nature's complexity. So we construct mathematical models and run them on computers, a process called simulation. In return for all that trouble, we get very large piles of paper with numbers on them that describe what happened. But a better alternative is to use a supercomputer to digest the massive amounts of numbers, then turn them into images similar to those on these pages. Software that can take the numerical product of complex models and translate it into easily interpreted images has made the computer much more appealing as a modeling tool. The advantages of supercomputers, mainly huge memory capacity and very high computational speed, have helped create a discipline that goes by the name computational science. Its

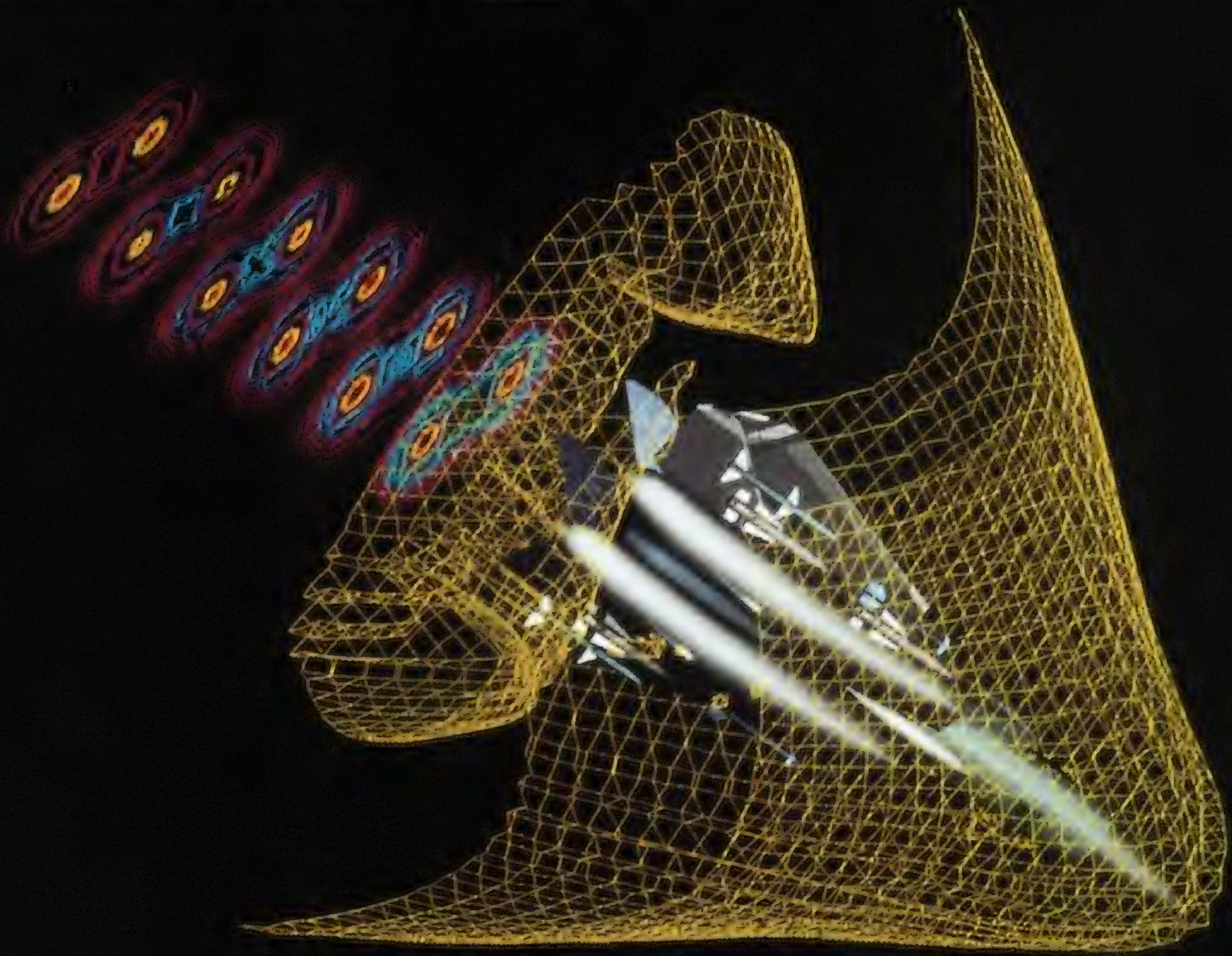
COMPUTER GRAPHICS COURTESY CRAY RESEARCH

Aerodynamicists need to know how airflow behaves around large adjacent forms like a space shuttle's external tank and solid rocket boosters. This computer image depicts airflow around an ascending shuttle better than if the vehicle were in a wind tunnel. In a tunnel, streams of smoke would merely delineate the air's path, but the computer can add colors. Here red indicates areas of high pressure.

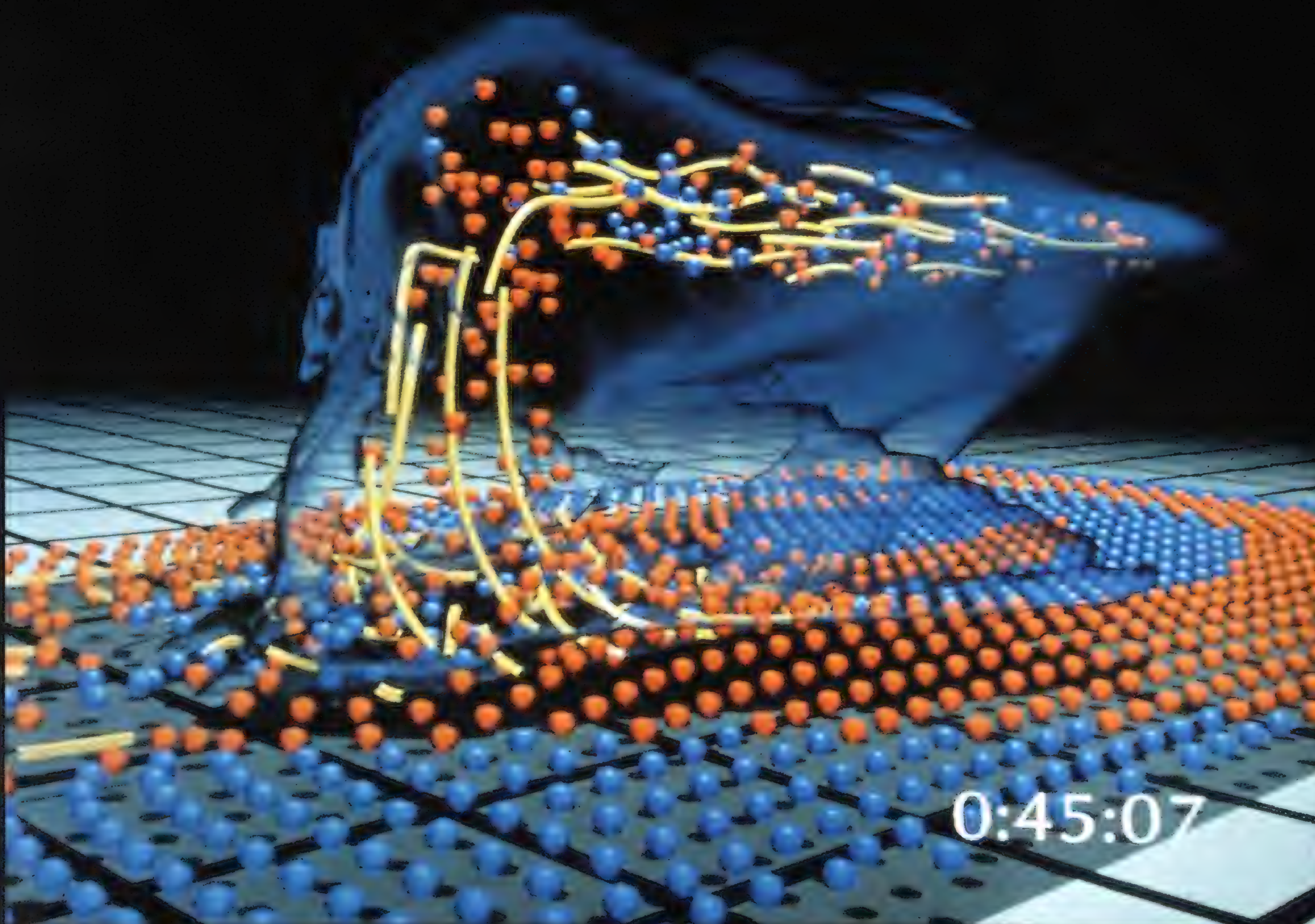
laboratories are the video screens from which these images are taken.

Before scientists and engineers had computers with enough capacity and speed to qualify as "super," they performed the same basic calculations that generated the models you see here. It just took them much longer to do much less. The Navier-Stokes equations describing fluid flow date back to the mid-19th century, so the math hasn't changed much. When engineers were armed only with slide rules, they performed those operations upon only one point, or perhaps a few neighboring points, in a complex system. The result of the calculation was therefore limited to describing what happened locally. And that limits science.

Take a shape as complicated as an entire airliner, or a fighter with missiles on its wings, or a space shuttle complete with solid rocket boosters and external tank, and move



In less than a second, a Cray supercomputer calculated thousands of solutions involving 64,000 "cells" of air to simulate an F-14 fighter in supersonic flight. The yellow fishnet, resembling a contour map, connects an array of points where the Mach number is 1.5, thereby revealing the shape of the airplane's shock wave. The forms surrounded by magenta aft of the airplane represent flow from the engine exhausts.



One way to visualize airflow within a developing severe storm is to introduce tracers represented by hypothetical weightless spheres. In this simulation, the spheres are initially set two kilometers (1.25 miles) apart. Orange indicates spheres that are moving upward; blue reveals those moving down. Some particles are tagged with yellow ribbons to trace their paths over time.

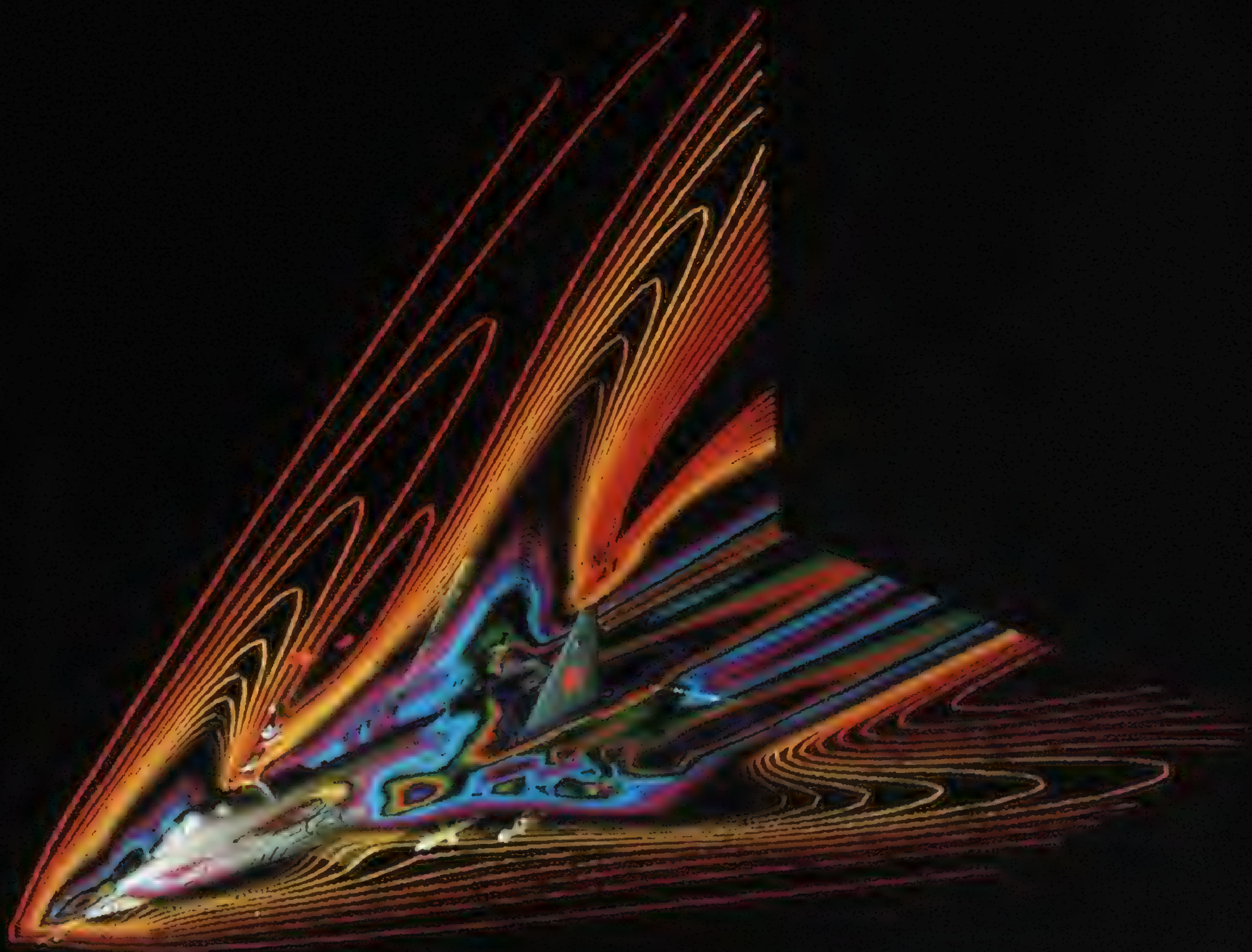
it through a mass of air. Scientists and engineers want to see what happens to the air as the entire vehicle passes through it, not just one point on the vehicle's surface. Traditionally, such experiments were performed by placing a model in a wind tunnel or flying an aircraft wired up with sensors. But tunnels and test flying have their own quirks and limitations, they take time, and they cost a lot.

Meteorologists confront a similar situation: a traditional, long-established calculation (such as Boyle's Law, which describes the relationship between pressure and volume) can compute a result for one point in a thunderstorm but can't model the whole storm.

Both aerodynamicists and meteorologists now use supercomputers to store and manipulate numerous points within a complex system of moving fluids. Aerodynamicists create a model describing the surface of, say, a MiG-29, then let the computer handle the enormous number-crunching chore of figuring out what the air does at hundreds of thousands of points around the aircraft. Meteorologists plot actual data recorded by weather observers to update their model, then run it to see what will happen to the weather systems. The higher the resolution—the more individual points the computer can handle—the more accurate the resulting model.

The working capacity of supercomputers is measured in "flop/s," or floating-point operations per second. A CRAY-1 supercomputer, like the one in the National Air and Space Museum's gallery "Beyond the Limits," could handle 160 million flop/s, and it cost $11.2 million when it first appeared in the 1970s. The EL, a new econo-supercomputer from Cray Research, can deliver 133 million flop/s but costs only $1.4 million today. So life may be getting more complex, but understanding it is getting simpler.

Contour lines around this Soviet MiG-29 represent the scale of Mach numbers from 0.5 to 1.5, with the maximum value colored red and the minimum blue. The airplane is represented within a block of 500,000 cells, and the supercomputer calculated the entire solution in less than five seconds.



Another simulation with resolution similar to that of the above MiG-29 involves an unusual aerodynamic shape: a pilot in an ejection seat. Contour lines show a shock at Mach 1.5 (red) centering on the pilot's feet, with low-speed flow near the upper body and aft of the back of the seat (blue). The simulations of the F-14, the MiG-29, and the ejected pilot were created using Numeric Electronic Wind Tunnel, or NEWTUN, a program written by a group at the University of Arizona, Cray Research, and Kirtland Air Force Base in New Mexico. Future simulations depicting airflow around an entire aircraft will require grids of a billion to a trillion cells, each cell requiring between six and a hundred 64-bit "words."

The airplane was old before it even flew.
Its manufacturers called it the Avro Type 696. To its crews, it was simply

THE SHACK

by Ron Dick

Photographs by Richard Winslade

In the end only five of them were still flying. Since 1972, Avro Shackletons had carried out the Royal Air Force's vital airborne early-warning (AEW) function, a mission they had assumed after they had already passed their expected retirement age. The measure was to have been an interim one, but the interim stretched into 20 years and by the time the aircraft finally stepped down they were some 40 years old. Last summer, I traveled to England to witness for myself the end of an era: the retirement of the last operational frontline piston-engine squadron in the world.

That the Shackleton, of all airplanes, would have such a protracted career could never have been imagined at the time it was developed. It all began on March 9, 1949, when Jimmy Orrell, chief test pilot of Avro, first flew the prototype Avro Type 696 at Woodford in Cheshire. His reaction to the initial flight was typically succinct: he said it "flew extremely well and had that comfortable feel of its predecessors, the Lancaster and Lincoln."

In many ways, the new aircraft was so much like its predecessors that it was obsolescent before it flew. The Type 696 was really nothing more than the logical evolution of a series of hefty Avro aircraft descended from the unreliable twin-engine Manchester bomber of 1939. From the ashes of that failure had leapt the brilliant four-engine Lancaster, the RAF's most successful bomber of World War II, and its larger offspring, the Lincoln. The Type 696, a modified Lincoln with a broader fuselage, was developed after the war and eventually named in honor of British Antarctic explorer Sir Ernest Shackleton.

The days when Britons could look up and spot a formation of Shackletons (left) ended last year, when the old piston-engine giants were finally retired. Those who knew the Shack best, such as Squadron Leader Roger Read (above), had mixed feelings for the noisy, uncomfortable, enduring aircraft.

Wing, tailplane, undercarriage, and even engines were recognizably of the Avro lineage, but the magnificent Merlin engines that powered so many Avros for so long were replaced with the larger but closely related Rolls-Royce Griffons. Last of the classic Rolls-Royce V-12s, the Griffon was designed to produce 2,450 horsepower and deliver it to a six-blade contra-rotating propeller—two three-blade propellers turning in opposite directions—measuring 13 feet across. Despite its power and the sheer spectacle of so many propeller blades in motion, the Griffon was a piston engine and its growl did not portend the future; it echoed the past.

If there was evidence of genetic change, it was to be found in the Shackleton's fuselage. It was distinctly portly, as if padded by blubber. When you thought about the airplane's intended role of maritime patrol, its cetacean shape seemed entirely fitting.

The struggle to keep shipments flowing across the Atlantic from the United States to Britain during World War II had dramatized the need for a maritime patrol landplane. Before the United States supplied RAF Coastal Command with B-17 Flying Fortresses and B-24 Liberators under a lend-lease agreement, Germany's submarines had nearly succeeded in cutting the Atlantic lifeline. By the end of the war these and other shore-based aircraft had destroyed 326 U-boats. The RAF had to return the U.S. aircraft at the war's end, however, and it needed replacements in a hurry. The simplest and quickest solution was to develop an aircraft based on a type that was already tried and tested. The choice was Avro's Type 696.

The decision was not merely expe-

dient. Postwar maritime aviators were not immediately attracted to the "higher and faster" promise of the jet engine. Maritimers made their living by flying "low and slow" for long periods of time, and first-generation jet engines were not particularly efficient at low altitude. Add the lack of knowledge about the ability of jets to withstand hours of exposure to salt spray and the distinct possibility of ingesting the occasional seabird at coastal airfields and it was understandable why the RAF went with a known entity. It wasn't alone in being so conservative: other prominent maritime patrol aircraft of the 1950s and early '60s, including the U.S. Navy's Lockheed P2V Neptune, the Soviets' Beriev Be6, and Canada's Canadair Argus, were powered by piston engines.

Still, there is no denying that the Shack went on grinding its way across the waves long after its contemporaries had given way to the turboprop generation. The Shack had turned out to be pretty good at its job, and even in the face of the increasing threat from the expanding Soviet navy, the RAF could think of better ways to spend its hard-fought share of the 1960s military budgets than buying a new maritime patrol aircraft before it was absolutely necessary. The more glamorous roles of air defense, ground attack, and nuclear strike were noticeably higher on the priority list.

Not that anyone was seriously worried about this delay. By 1970 even RAF maritime aviation was due to face the future, with the Shackleton to be replaced by the four-jet Hawker Siddeley Nimrod. Crews savored the prospect of the Nimrod's quiet cabin and the end of what Squadron Leader Kevin Byron of No. 8 Squadron described to me as "long grinding flogs out to patrol areas off the edge of the earth."

Then the unpredictable hand of politics intruded. Budget cuts made during the 1960s struck all the services,

On alert for unfriendly aircraft, AEW Shacks served to keep Britain's airspace as tranquil as its countryside.

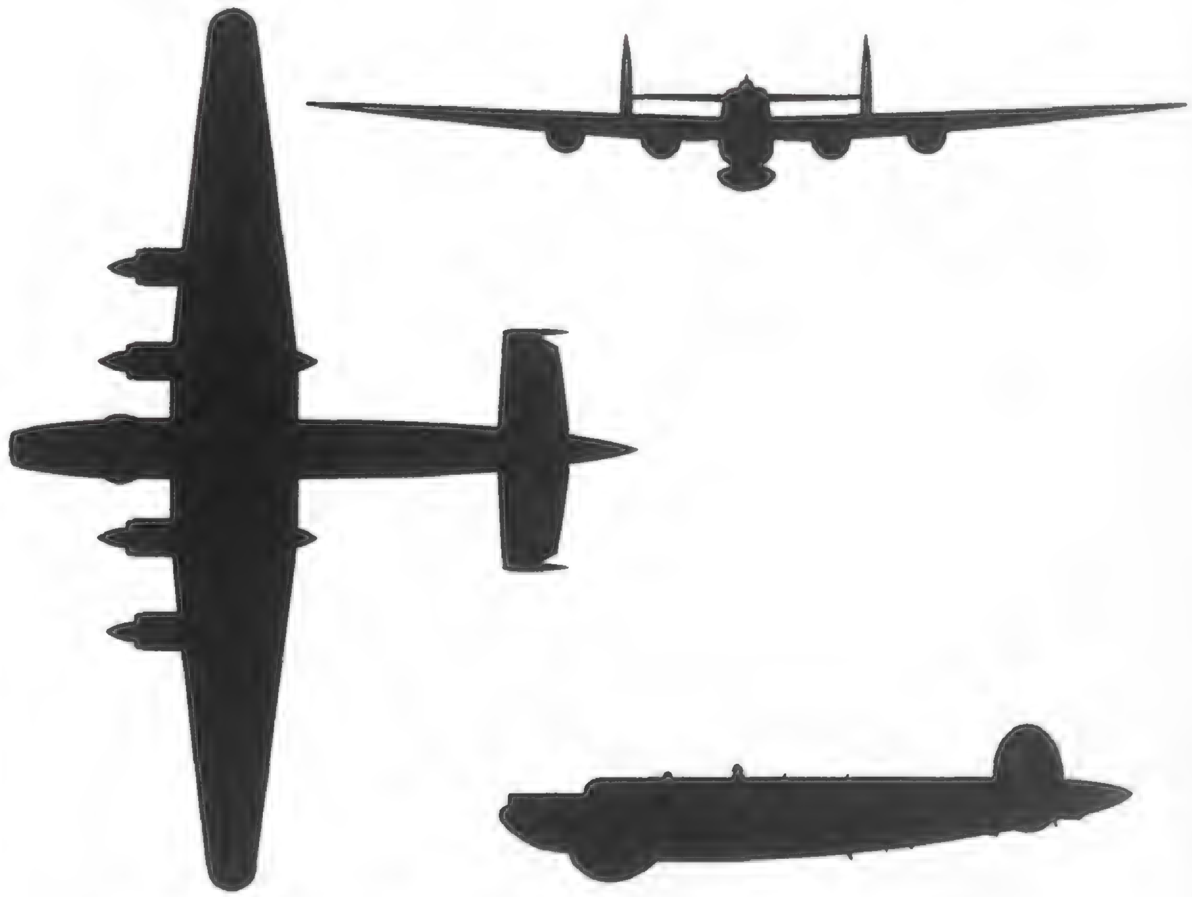
but the RAF and the Royal Navy contributed to their own suffering, each seeking to discredit the other's long-term plans. Both were remarkably successful. The navy was especially peeved when the RAF helped scuttle proposals for a new generation of aircraft carriers by insisting that land-based aircraft could more than adequately cover the navy's ships.

More to the point, the RAF said that it could provide airborne early warning for the fleet. Plans were duly made to phase out the navy's AEW aircraft, the Fairey Gannet, even though a suitable RAF replacement was not yet on the horizon. In a move that hinted at a measure of desperation, a stay of execution was announced for 12 Shackletons. As an "interim solution," they were fitted

with AN/APS-20 radars from the navy's Gannets and thus transformed into the United Kingdom's AEW force—for "only a short time," according to the Ministry of Defence.

In 1972 these AEW Shacks were assigned to the RAF's No. 8 Squadron and moved to the air base at Lossiemouth on the northeast coast of Scotland. Although still instantly recognizable as Shackletons, they had sprouted large, bulbous radomes directly beneath the cockpit, where the venerable radar was housed.

On guard with their fighter colleagues against low-level penetration of U.K. airspace, the Shackletons began lumbering off over the seas to the north of the British Isles at all hours and in all weather. Their principal quarry was the Soviet Tupolev Tu-95 reconnaissance aircraft. Tu-95s were known by the NATO reporting name of "Bear," and



Avro Shackleton AEW

Twelve Mark 2 Shackletons, the second of three types produced, were modified in 1971 to carry out airborne early-warning (AEW) duties for the Royal Air Force. Powered by four 2,450-horsepower Rolls-Royce Griffon engines, the Shacks had a range of 3,800 miles at 200 mph. The radome under the cockpit held an AN/APS-20 radar.

The Shack's immense contra-rotating props, here set in motion for a farewell flight, are its most distinctive feature.

Fun With Mr. McHenry

In the 1960s and '70s, the BBC aired a gentle little television program called "Magic Roundabout." Although intended for the very young, it gained something of a cult following among adults, including some in the Royal Air Force. Thus it was that when I met the five surviving Shacks at Lossiemouth in the days shortly before their retirement, I was introduced to Florence, Parsley, Brian, Mr. Rusty, and Mr. McHenry, each of the lumbering aircraft having been named after a character from the program.

To my delight, I was invited to take a short flight in Mr. McHenry and spend some time on the flight deck to get the feel of it. As I climbed in through the fuselage door, I noticed that the aircraft showed its age. Coverings on the crewmen's seats were frayed, and there were shiny patches of metal showing where paint had been worn away by hundreds of boots and gloves. The crew compartment, not spacious, had the comforting smell of old aircraft, with undertones of aviation fuel.

Engine start was the usual exciting business it always is with big piston engines, a combination of some dispassionate moving of switches and levers and a lot of emotional encouragement of each engine as it turned over. Each awakening was enlivened further by the sight of the immense contra-rotating props, which, before the engine fired, resembled huge sets of scissors opening and closing.

Once running, the four Griffons immersed the aircraft in their sound and set everything vibrating. At takeoff power, their urgent fury dominated the senses, but at cruise settings their heavy growl and shake soon felt normal.

Wing Commander Chris Booth, No. 8 Squadron's commanding officer, was in the right-hand seat, and he warned me that I "might find the Shack fairly heavy on the controls." He was right: moderately large movements were needed to make anything happen at all, and they demanded a fair amount of muscle. Nevertheless, the aircraft was pleasant to fly; it trimmed easily and went where it was put, provided that a certain amount of aiming off was done when rolling out of turns. On the approach, begun from downwind at 140 knots (about 160 mph), the aircraft had a satisfyingly solid feel, and, when it was properly trimmed and at suitably steady power settings, the speed bled off gently enough to 120 knots (about 140 mph) at 200 feet.

The only unusual factor here was the aircraft's long snout, which, during landing, effectively blanked out half of each pilot's view. Chris Booth insisted that such a single-sided view was not a problem, unless "there is a screaming crosswind from the wrong side and a brand-new copilot in the other seat." Fortunately for me the wind was negligible, and with the stick fully back at touchdown, the Shack settled ponderously onto its undercarriage much like a large man settling onto a waterbed.

Taxiing was a bit trying. Too much brake or throttle made the beast eager to leave the taxiway for open pastures. More judicious and gentle use of the controls proved the key to avoiding embarrassment.

Finally, as the shutdown checks were completed and various equipment was shut off, the shrieking, whining, whirring, and grumbling of the living Shack slowly stilled. After the Griffons fell silent and the scissoring propellers whistled to a stop, the atmosphere was peaceful again, and a little sad.

the squadron duly earned the nickname the Bear Hunters. While acknowledging the limitations of the aging Shacks and their even older radars, Kev Byron told me that "on a good day the Shack could pick up a Bear at 220 miles before guiding the fighters forward to escort him off the home patch."

Nevertheless, the crews had a love-hate relationship with the old airplanes. "The Shack hardly ever let us down," Byron said, "but there is no getting away from the fact that it was not a comfortable place to work. It was noisy and drafty, and the trips could be incredibly boring." Squadron members confided that they would remember their endless patrols for "the everlasting vibration" and "the pervasive drafts" and "the puddles everywhere" that appeared when rain forced its way through countless leaks. The crews described their Shacks as "uncomfortable but unique."

The belief that change was on the way in the form of new aircraft helped make the task more bearable. In the early 1970s negotiations started on the acquisition of 18 Boeing E-3 AWACS (Airborne Warning and Control System) craft for NATO. The United Kingdom was part of the NATO team, but endless wrangling between the allies over the AWACS specifications and who would pay for what dragged on into 1976. By then some doubted whether an agreement could be reached at all. At that point the United Kingdom decided in exasperation to go it alone with another aircraft, an AEW version of the already proven Nimrod.

It was now obvious to No. 8 Squadron that there would be no relief. The Shack was going to have to last into the early 1980s, and the "interim solution" might stretch into its second decade.

Stretch it did. The Nimrod AEW looked promising enough, and the modified airframe first flew in 1977. But from then on it became a technical nightmare, and by 1986 its development was five years behind schedule, with no end in sight. In response to the RAF's pleas, the project was canceled and a separate order was placed with Boeing for seven E-3 Sentries.

The Shacks of No. 8 Squadron growled on. By 1981, economizing and the wear and tear of 30 years on the frontline had reduced the squadron to six aircraft, all of which had been extensively refurbished on the assumption that they still had quite a way to go. The 1986 decision to buy the Boeings finally told the squadron just how far: it wouldn't be until 1991 that the nearly 40-year-old Shacks could stop growling.

By the time they retired, each of the surviving airframes had accumulated some 15,000 hours in the air (a relatively low figure by civil airline standards). They were clean and smart, and to my surprise, the engineers said they had had few real problems in keeping them serviceable. The squadron's senior engineer, Ian Waterhouse, told me they had "had enough time to get used to the Shack and its little ways" and assured me that "spares were not a problem, especially since those from the whole of the original Shack fleet were now being lavished on only five aircraft." (One of the remaining six was lost in 1990, when it flew into a cloud-covered hill in west Scotland.)

During a trip to the United States early last year, however, one of the squadron's Shacks had an experience that served to remind the crew of their airplane's

unusual status. The four Griffon engines were down on oil after the long haul across the North Atlantic. When the crew, used to dealing with oil measured in Imperial gallons, called for piston-engine lubricating oil, the airport fuel truck obliged—with cartons of oil packaged in quart containers. A *drum* of oil? None seen in these parts for years. The crew patiently set about opening individual quart containers, musing no doubt on the rare sight the Shack must be in a land where the horsepower of most reciprocating aircraft engines is measured in the hundreds.

The big Griffons, of which there seemed to be no shortage at No. 8 Squadron, were routinely changed every 1,300 hours. The only serious maintenance problem in memory had cropped up in the 1980s, when the RAF ran out of replacement display units for the AN/APS-20 radars. The problem was not solved until an American entrepreneur turned up out of nowhere and announced that he had a hangar full, bought years ago from U.S. Navy surplus. A true Anglophile, he said he was "only too glad to part with them at cost to keep the U.K.'s AEW force in the air."

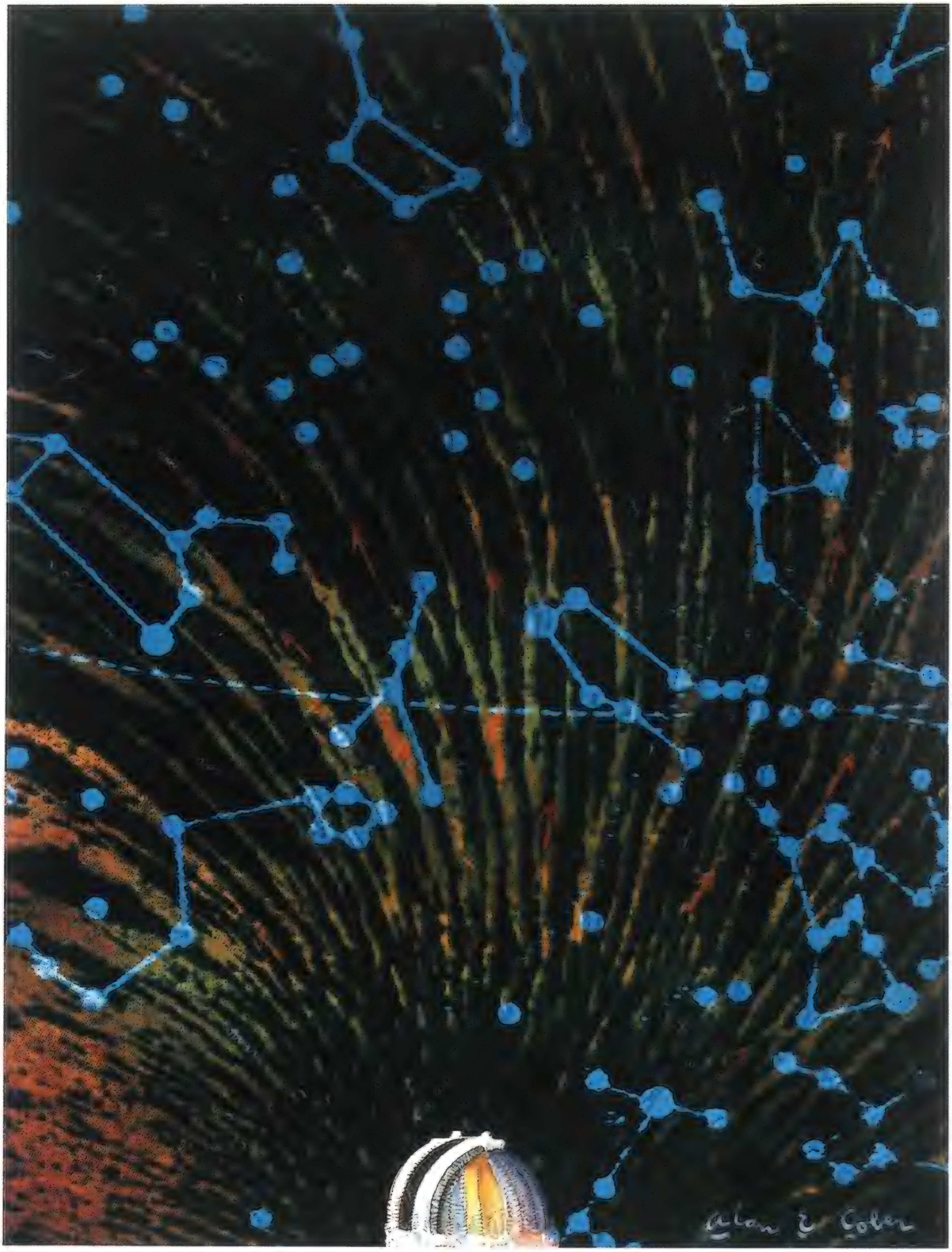
Despite its age, the Shack proved relatively easy to maintain; after some 40 years in service, the airplane did little to surprise its engineers.

Many members of No. 8 Squadron retired with the Shackleton. Others have been retrained for the Shack's replacement, the Boeing E-3 Sentry.

A few days after their retirement on June 30, 1991, four of the five surviving Shackletons came under the distinguished gavel of an auctioneer from Sotheby's. Each went for a paltry £40,000 (about $75,000), less than the value of their engines alone. Two were bought by a Cypriot businessman and flown to Cyprus. The other two were bought by the Shackleton Preservation Trust, a private organization of British Shack buffs that intends to keep one in flying condition. The RAF kept the remaining Shack and sent it to Cornwall, where it will be used for ground training.

Many of the crew chose to retire when the Shack did, but others are at RAF Waddington, assigned to the Shack's E-3 Sentry replacements. "The Shack was a wonderful old machine, but you can't compare it with a new E-3D, which is a supurb piece of kit," says Flight Lieutenant Dave Marshall, a navigator. "The biggest difference for me [was that the Shack] was an old smelly aircraft and the new one is modern. You're not bounced around, not hot. It's very pleasant to fly. A lot more comfortable."

"The new airplanes do the job and are vastly superior, and it allows us to do our mission extremely effectively," says Flight Lieutenant Andy Thomas, a tactical director on the E-3. "The Shack was an airplane out of its time. It served the Queen, the RAF, almost 40 years. A good servant—the taxpayer got his money out of it. Yes, it's sad to see them go, but it was time."


Alan E. Cober

Ancient Whisper

It takes an extraordinary satellite to eavesdrop on the beginning of everything.

by Billy Goodman

Illustrations by Alan E. Cober

In the days preceding the January 1990 meeting of the American Astronomical Society, the members of the Princeton University physics department noticed that David Wilkinson seemed pretty excited about something. As physicist James Peebles remembers, he had never seen Wilkinson looking so pleased. "He carried in his pocket a wrinkled piece of paper," Peebles says, "and he would pull you into a corner and show it to you."

The paper contained a graph of preliminary data from a NASA satellite, the Cosmic Background Explorer, which had been launched from California's Vandenberg Air Force Base the previous November atop a Delta rocket. As a member of the COBE science working group, Wilkinson had been sworn to secrecy—but he couldn't resist showing the wrinkled piece of paper to fellow professor Peebles.

Because the COBE team wasn't scheduled to present their data until the last day of the AAS meeting, some members of the team wondered how many people would still be around to listen to their talk. But when project scientist John Mather walked to the front of the lecture hall that Saturday afternoon, more than a thousand scientists were waiting.

Mather, who looks more like a lanky graduate student than the leader of a team of 20 scientists, had prepared several viewgraphs for his presentation. The assembled scientists saw a graph charting the energy theoretically left in the universe from the moment of creation. Then Mather took the graph that had given Wilkinson such pleasure and superimposed it. Every single one of the 67 data boxes lay centered on the predicted curve.

The assembled astronomers, who are accustomed to some degree of error in experimental measurements, rose to their feet and burst into spontaneous applause. The graph, after all, was resounding confirmation of the Big Bang, a theory that describes no less than the birth of the universe (see "The Big Bang," p. 56).

Wilkinson was one of the first to search for remnants of the Big Bang, so he was especially gratified to see support for his work. "Like others, I kept asking myself, 'Did we miss something? Are we on the right track?' " he recalls. "COBE resolved that—we really are on the right track."

Wilkinson was new to the Princeton physics department in 1964, the year a key piece of evidence supporting the Big Bang theory fell into place. Modern cosmology—the study of the universe—was still in its infancy in the early 1960s, and astronomers were busy measuring the motions of distant galaxies in an attempt to elaborate on Edwin Hubble's 1929 observation that the universe is expanding. At the time, the Big Bang was just one of several theories explaining the origin of the universe. Its leading rival was the steady-state model, which postulated that the universe does not change over time—that new matter is continually created to fill the gaps created by outward-streaming galaxies. No astronomical observations had been made to support either the Big Bang or steady state, or any variations of the two.

Wilkinson and Peebles were part of a research team led by Robert Dicke, a leading physicist at Princeton. Dicke believed that some of the Big Bang's heat—its thermal radiation—should still exist. Wilkinson recalls Dicke saying to his young colleagues, "Why don't you guys go look for this remnant of the Big Bang?"

The research team was excited about the idea. *If the background radiation was there,* Wilkinson remembers thinking, *it would revolutionize our idea of cosmology.* "The only question," he says, "was what were the chances of seeing it? I believed it was about fifty-fifty."

Unbeknownst to Dicke, his ideas had been anticipated 17 years earlier. Ralph Alpher and Robert Herman, two young physicists who by day worked on military contracts at the Johns Hopkins Applied Physics Laboratory near Washington, D.C., had devoted their evenings and weekends to devising a theory of the early cosmos. Starting in 1948, they published a series of papers predicting that the heat radiated in the explosive

origin of the universe should still be measurable with highly sensitive receivers. Ironically, one of their papers, published in the prestigious journal *Physical Review,* had appeared only pages from one Dicke had written—ships passing in the night.

Inspired by their mentor, the great astrophysicist George Gamow, Alpher and Herman had argued that the early universe would have produced what is known as blackbody radiation—heat and light in equilibrium with heated matter. For any given temperature, the radiation a blackbody emits is predictable at every wavelength. As the universe expanded, the wavelengths of the visible radiation would have been stretched—redshifted—into microwaves, which fall between radio and infrared waves on the electromagnetic spectrum. Alpher and Herman had calculated that the temperature of that glow should be around five degrees Kelvin (only nine degrees Fahrenheit above absolute zero, which is -459.67 degrees Fahrenheit).

Working along similar lines, Wilkinson and Princeton researcher Peter Roll set to work constructing a horn-shaped antenna and detector to measure radiation at the microwave wavelength of 3.2 centimeters. They hoped that their measurement would fall along the curve predicted by blackbody radiation. By the fall of 1964 the horn antenna was finished. Because it was necessary to shield the radiation detector from the 300 degrees Kelvin that Earth itself radiates, the final design resembled a musical instrument on steroids.

To calibrate its measurements, the radio telescope also needed a "cold load"—a reference source whose absolute temperature was known. The group decided on a helium load—a spongy material saturated with liquid helium at a temperature of about four degrees Kelvin.

Proper calibration of the telescope was crucial in the search for cosmic background radiation. "Ordinarily in radio astronomy you point the antenna at a source, then move it slightly away to look at blank sky," explains Wilkinson. "The difference between the flux at the source and the flux at the blank sky is the flux *from* the source. But you can't do that with the cosmic background radiation, since it comes from everywhere. You want to put a known source, the cold load, over the horn."

Though the Princeton physicists had no idea, two radio astronomers at AT&T Bell Laboratories, just 30 miles up the road in Holmdel, New Jersey, were about to reach the same goal from a different direction. Arno Penzias and Robert Wilson, searching the Milky Way for radio waves with a 20-foot horn radio antenna, had been struggling to rid their instrument of an unwanted hiss, one generated from something with a temperature of about three degrees Kelvin. The noise persisted no matter where in the sky they pointed their antenna. That meant the noise was either pervasive in space—cosmic—or produced somewhere in the antenna or instruments themselves.

Perplexed by the hiss, the Bell scientists taped the seams of their antenna. They also removed a pair of pigeons that had deposited a "white, dielectric material" inside the horn. Still the noise persisted.

In December 1964, Penzias heard about an unpublished manuscript by Peebles that predicted background radiation of roughly 10 degrees Kelvin, similar to what Alpher and Herman had predicted. Penzias called Robert Dicke.

As Wilkinson recalls, he and the rest of the research group were in Dicke's office eating lunch when Penzias called. "When we heard the words 'helium load,' we knew it was an important conversation," he says. When Dicke got off the phone, he said, "Well boys, we've been scooped."

The two groups agreed to publish complementary papers. Penzias and Wilson described the excess radiation their antenna had detected. Dicke and his colleagues wrote an accompanying paper explaining what the Bell lab scientists had found.

When Penzias and Wilson won the Nobel Prize in physics in 1978 for their discovery, there was a bit of disappointment around the halls of the Princeton physics department. Hardest hit, however, were Alpher and Herman, whose prescient prediction had apparently been ignored by the Nobel committee. Wilkinson is philosophical about the award. "The great thing about science is that you don't have to be Einstein to make a great contribution," he says. "Careful work is also rewarded. You've got to give Penzias and Wilson credit. They were seeing something they didn't understand, that wasn't part of their goal. Yet they stuck with it."

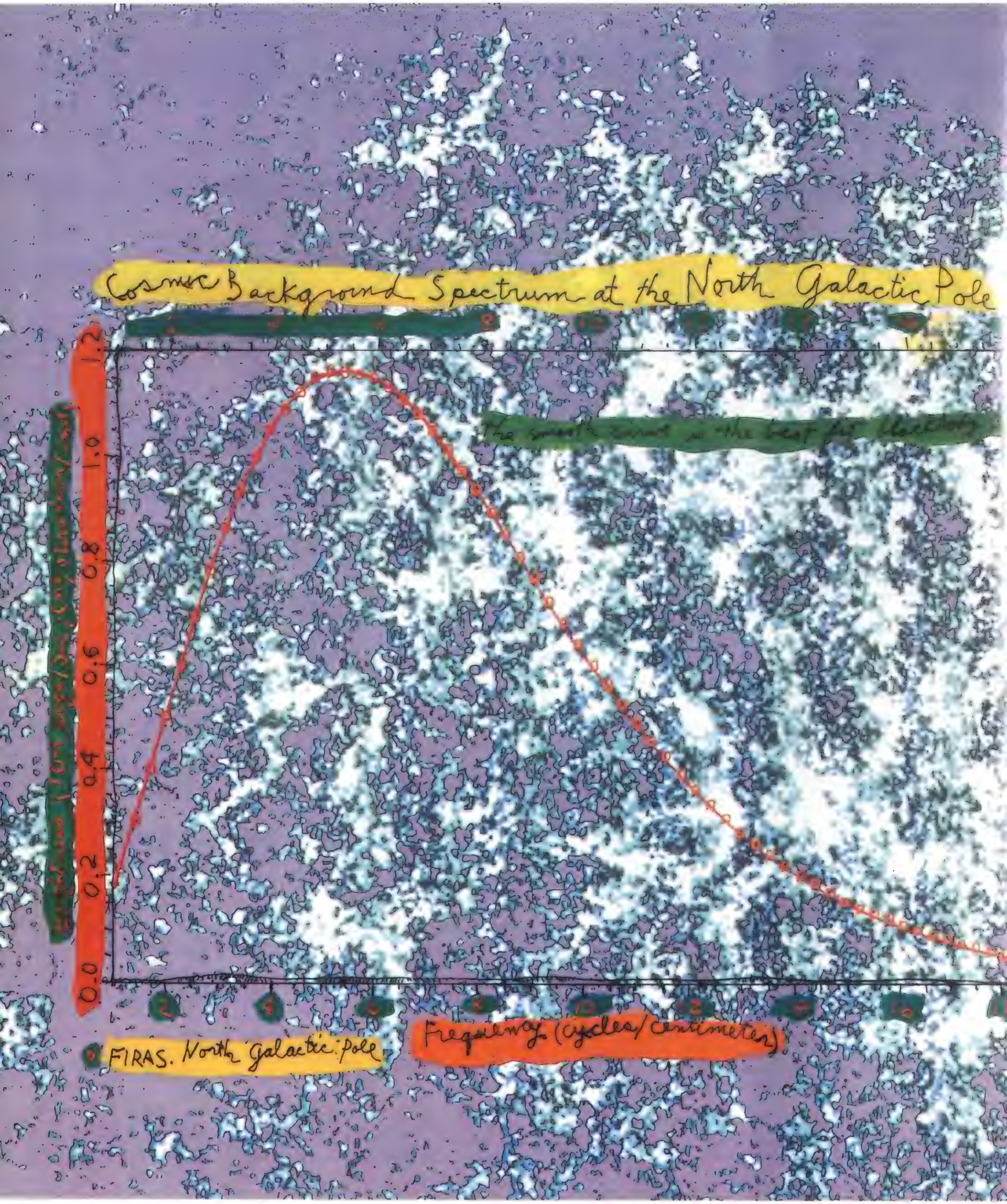
Penzias and Wilson had measured the radiation at just a single wavelength—7.35 centimeters. Further measurements would be needed at other wavelengths. If the cosmic background

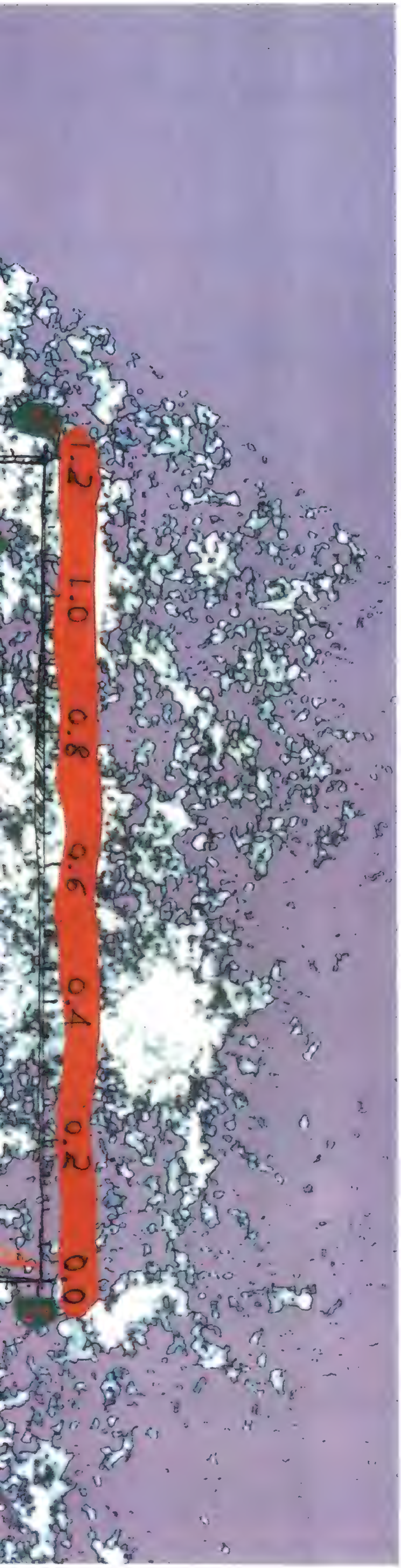
The Big Bang

According to the Big Bang model, the universe began in a rapid expansion from an incredibly hot, dense state about 15 billion years ago. How hot and dense? The question almost doesn't make sense, since physicists believe that current laws of physics may not have applied that close to the universe's beginnings.

Things become a little more predictable one-hundredth of a second after the Big Bang's violent explosion. At that point the temperature dropped to 100 billion degrees Kelvin. Matter existed only as an ionized plasma, with electrons and protons whizzing about. When protons captured electrons, atoms of hydrogen formed. Just as quickly, hot, energetic photons of radiation collided with the atoms and tore them apart. These collisions ensured that matter and radiation were thoroughly mixed and the same temperature throughout.

As the universe expanded for the next 300,000 to 500,000 years, its temperature dropped to about 3,000 degrees Kelvin—roughly half the temperature of the sun's surface. At that temperature photons no longer carry enough energy to rip apart atoms into electrons and protons, so hydrogen atoms were able to form and survive. The atoms were largely transparent to photons, which have been traveling outward ever since the universe began expanding. These photons, first detected as microwaves by AT&T Bell Laboratories radio astronomers Arno Penzias and Robert Wilson, have been confirmed by COBE to be proof of the Big Bang.


Cosmic Background Spectrum at the North Galactic Pole
The smooth curve is the best fit
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Frequency (cycles/centimeter)
FIRAS. North Galactic Pole



radiation was indeed blackbody radiation, its frequency and intensity should match the blackbody curve found for any radiation produced under thermal equilibrium conditions, such as occurred following the Big Bang.

The Princeton group soon contributed a second measurement at 3.2 centimeters—also on the blackbody curve. Both data points, however, fell on the long-wavelength portion of the curve that can be detected from Earth. Because of atmospheric interference, using ground-based instruments to make measurements at the short end of the spectrum promised to be difficult, if not impossible. "It was clear very early on that one needed to get into space," says Wilkinson.

Within a few years of the discovery of the background radiation, researchers began placing detectors on balloons and rockets. These experiments continue today, but because they're short-lived they don't allow much time to determine the source of a signal. It's hard to determine how much is actually from background radiation and how much comes from other sources, such as galactic dust, electrons zipping around in galactic magnetic fields, and noise from the instrument itself.

In 1974, when NASA issued Announcement of Opportunity #7 for space-based science projects, the agency was swamped with proposals from scientists who wanted to study cosmic background radiation. NASA later directed three teams of researchers to collaborate. A young astrophysicist named John Mather from the Goddard Space Flight Center in Greenbelt, Maryland, was named the study scientist. Mather, Wilkinson, and several other scientists had submitted a proposal for a satellite that would carry instruments to an altitude of 560 miles in order to improve the measurement of background radiation. This proposal became the core of the most ambitious attempt to date to learn about the Big Bang and the evolution of the universe.

From the beginning, COBE presented some difficult technical challenges. The two-story satellite has three main instruments: the Far Infrared Absolute Spectrophotometer, the Differential Microwave Radiometer, and the Diffuse Infrared Background Experiment. To keep COBE's own heat, as well as the radiation in space, from drowning out the whisper of creation, the designers nestled two of the three instruments inside a sophisticated refrigerator called a cryostat, which is cooled to 1.4 degrees Kelvin by 160 gallons of liquid helium. Building equipment that functioned at such low temperatures was a frustrating task, says deputy project manager Dennis McCarthy. "We would get things that worked at room temperature and would just stop at 2 K," he says. "We had close to 100 percent failure rate in the instruments the first time because of the cryogenics."

One problem on the Far Infrared Absolute Spectrophotometer, the instrument that precisely measures the spectrum of the cosmic background radiation, almost killed it. FIRAS uses a 4.5-foot-long horn to capture radiation and funnel it to the detectors, which are tiny silicon resistance thermometers glued to a piece of blackened diamond deep inside the cryostat. A calibrator shaped like a trumpet mute fits tightly into the horn's mouth and is heated to a specific temperature so the detectors can be checked.

But the launch schedule was delayed and the calibrator movement could not be checked until FIRAS was installed in the cryostat. When finally tested, the calibrator didn't fit tightly.

The fix was simple: open up the cryostat and replace a cable—though finding a cable that worked was tricky. The repair cost a few months, at perhaps $1 million a month. Had the mistake not been caught, data from FIRAS would have been worth little.

While Mather and the COBE scientists struggled with their satellite, a team of scientists from the University of California at Berkeley and Nagoya University in Japan had launched a rocket to measure cosmic background radiation. In 1987 they reported a surprising intensity. Although two data points were only slightly above the blackbody curve, the amount of energy needed to create the deviations was large. "Since it took a cataclysm to make the cosmic background radiation, it would have taken a mini-cataclysm to make all the extra energy," says Mather. "No one knew what that could be."

That didn't stop theorists from proposing ideas in dozens of papers spawned by the Berkeley-Nagoya experiment. Scientists began to speculate that the large-scale structure of the universe, with its apparently uneven density of luminous matter, might have been determined by explosions that occurred soon after the Big Bang and blew matter outward.

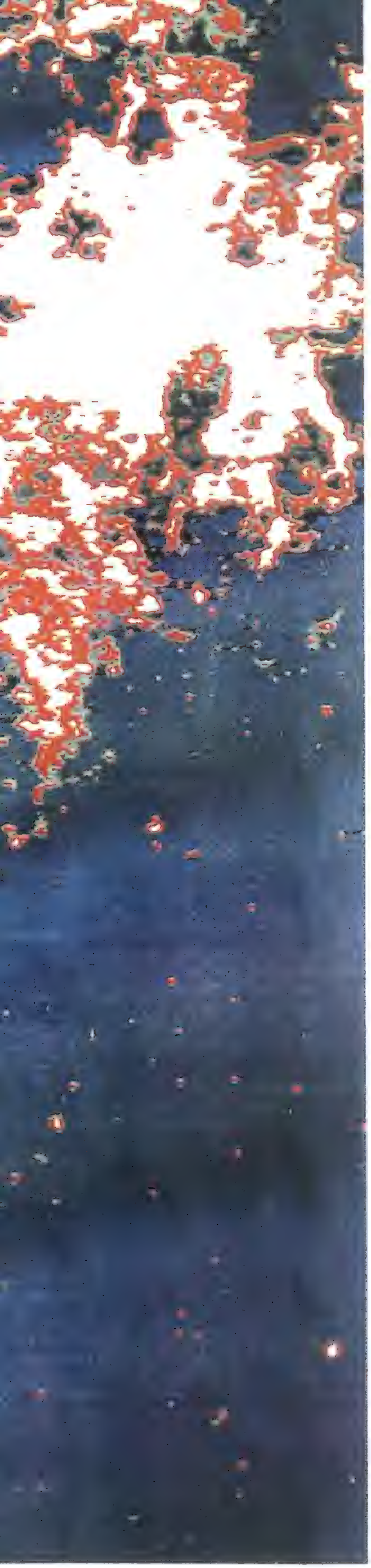
Whatever the case, scientists hoped that data from COBE's instruments would help explain the discrepancy. Cosmologists were especially eager to receive the data from FIRAS, which would provide the most complete measurements of the background radiation spectrum.

COBE was lofted into space on November 18, 1989, and several weeks later FIRAS completed nine minutes of measurements. It was this data that gave Wilkinson such glee and earned Mather a standing ovation at the AAS meeting in Arlington, Virginia.

How does Mather explain such an uncharacteristic response from skeptical scientists? "People were relieved by the results we got," he says. Although the Berkeley-Nagoya findings didn't put the Big Bang itself in doubt, Mather says, they did suggest that something exotic had happened in the early universe, perhaps the creation and subsequent explosion of supermassive objects or large numbers of black holes. The COBE data ruled out such explanations for the large-scale structure of the universe.

While FIRAS gave scientists renewed confidence in the Big Bang, other mysteries remained. How, for example, did the structures we observe today—stars, galaxies, clusters of galaxies, even clusters of clusters—emerge from the apparently featureless Big Bang?

"The question becomes what happened after the Big Bang in the evolution of the universe," says Goddard Space Flight Center's Charles Bennett, the deputy principal investigator for the Differential Microwave Radiometer. "We know structures began to form. At some point matter began to condense," he explains, "and that should affect the apparent temperature of the cosmic background radiation." Astronomers



hope that the DMR will reveal warmer spots in the background radiation, where the universe was initially slightly denser than average. These tiny temperature irregularities might prove to be seeds of galaxies.

It seems peculiar that, as Wilkinson puts it, "we know a lot more about the early universe than the adolescent universe." The best model of later structure—and therefore the one with both staunch proponents and staunch detractors—is based upon cold dark matter. It postulates that most of the matter in the universe is made of particles that have yet to be directly detected (hence dark) and are relatively cold compared with, for example, bright stars.

If cold dark matter exists, it would betray its presence through temperature differences in the background radiation. Taking into account the apparent temperature change due to Earth's movement through space, no one has yet detected differences as large as one part in 10,000 between one point in the sky and another. "If we don't see fluctuations at about one part in 100,000, there's no obvious way to modify cold dark matter to explain that," says Bennett. "We're not quite at the level where we can say cold dark matter is dead, but it's getting uncomfortable."

Others caution against prematurely announcing the death of cold dark matter. J. Richard Gott, an astrophysicist at Princeton, agrees that as COBE lowers the limit on temperature fluctuations, it squeezes the cold dark matter model. He points out, however, that one version of the model predicts temperature fluctuations of only one part in 200,000, which is consistent with what COBE has found so far.

In addition to looking for seeds of early galaxies, scientists are searching for a background glow that might be further evidence of early galaxies. Rather than appearing in microwave, however, the glow will be apparent in infrared wavelengths, the subject for COBE's Diffuse Infrared Background Experiment. "A clue to how much matter actually condensed to luminous objects is how much luminous energy [the matter] emitted," says DIRBE principal investigator Michael Hauser. "A very bright infrared glow would suggest a great deal of matter was luminous, more matter than we can presently account for in stars and galaxies. It would suggest lots of dead galaxies or black holes, something that is invisible now. That would be a dramatic discovery."

Since Earth's atmosphere prevents ground-based detection of an infrared background, DIRBE is charting new ground. But even with COBE the task is daunting, since numerous strong infrared signals in the foreground can swamp anything dim in background. If DIRBE is able to detect an infrared background, Hauser says it will provide "another cosmic fossil that constrains our model-building of how the universe has evolved."

The liquid helium that enabled FIRAS to make its measurements has evaporated as expected, but the DMR and some of DIRBE's channels continue to record data. Years of data remain to be analyzed, and COBE scientists continue their daily battle to overcome thermal noise in the receivers and to understand systematic errors that hinder detection of the faint background signal.

"It's an exciting time," says Bennett. "We have the audacity to think that from this planet, we can measure enough stuff to know about the whole universe—how it was born and how it developed. What attracted me to COBE is that it's really making the fundamental measurements. You're not measuring the tail wagging the dog, you're measuring the dog."

Still, there's part of the dog that COBE can't measure. Because the satellite's detectors are limited to wavelengths of less than one centimeter, astrophysicists will continue to raise interesting questions about cosmic background radiation for some time to come.

David Wilkinson is not a scientist to let a question remain unanswered. To look where COBE cannot, he and graduate student Suzanne Staggs have built a detector to measure cosmic background radiation at 21 centimeters. The first step in the task is subtracting atmospheric interference. Wilkinson knows where to find the best instrument for that job. It's just 30 miles up the road from Princeton—the Bell Laboratories' horn antenna in Holmdel, New Jersey.

THE AIR CAMPAIGN

How do you pull a generation of paying passengers away from the railroads and into the air? Advertise.

by Michael Maxtone-Graham

ILLUSTRATIONS COURTESY NASM

In 1927 Henry Ford ran a brilliantly successful advertising campaign for something that didn't exist, that he would never own, and from which—though he tried—he would never make a dime. Placed in 10 U.S. magazines, the advertisements were designed to sell not a product but an idea—air travel. Ford had a considerable image problem to overcome.

After World War I, Americans knew the airplane by its role in two very different enterprises that frequently led to the same result: the death of the pilot. For most Americans, the best chance to see a real airplane was to pay admission to watch a barnstormer's perilous stunts—the more perilous, the more profitable for the showman. The rest of the country could at least read about airplanes in newspapers, since hardly a month went by without a report of casualties in the airmail service. Of the 40 pilots hired by the Post Office Department in 1918, only nine were left in 1925. So in May 1927, when one of those intrepid aviators climbed into an airplane and flew across the Atlantic to Paris, he merely confirmed what Americans already suspected: people who flew airplanes were either crazy or heroes. Charles Lindbergh certainly demonstrated that Americans could get caught up in the romance and excitement of aviation, but his flight alone could not have persuaded most

of them to join him in the air.

Before 1927 even the biggest airplanes were still flimsy affairs made of wood and canvas. The few brave individuals who hired one had to sit uncomfortably bundled and goggled in an open cockpit. Travel by train and ship, on the other hand, was comfortable, familiar, and safe.

William B. Stout took an important step toward winning the public's confidence in air travel in 1922, when he founded the Stout Metal Airplane Company in Detroit. A brilliant engineer and promoter, Stout had the bold idea that once he established a reliable freight service using all-metal aircraft, scheduled flights for passengers might become a practical next step. No stranger to a bold idea, fellow Detroit resident Henry Ford agreed.

By the time Ford and Stout began their collaboration, Model T automobiles were everywhere and Ford was revered as a captain of industry. The auto baron's support, therefore, conferred respectability as well as capital. "This whole picture," he told Stout in 1924, "looks to me as if it was something that somebody has got to put a lot of money behind to make an industry out of it. I don't know why the Ford Motor Company shouldn't do just that." Ford quickly bought the company and geared the project up for production, with Stout serving as a consultant.

Two years later, on June 11, 1926, the Ford Motor Company introduced the first gleaming, corrugated aluminum alloy Ford Tri-motor. The aircraft had a wingspan of 70 feet and carried an unheard-of eight passengers—inside! There was even a separate space for freight. And the Tri-motor could reach an altitude of 15,000 feet and cruise there at around 100 mph.

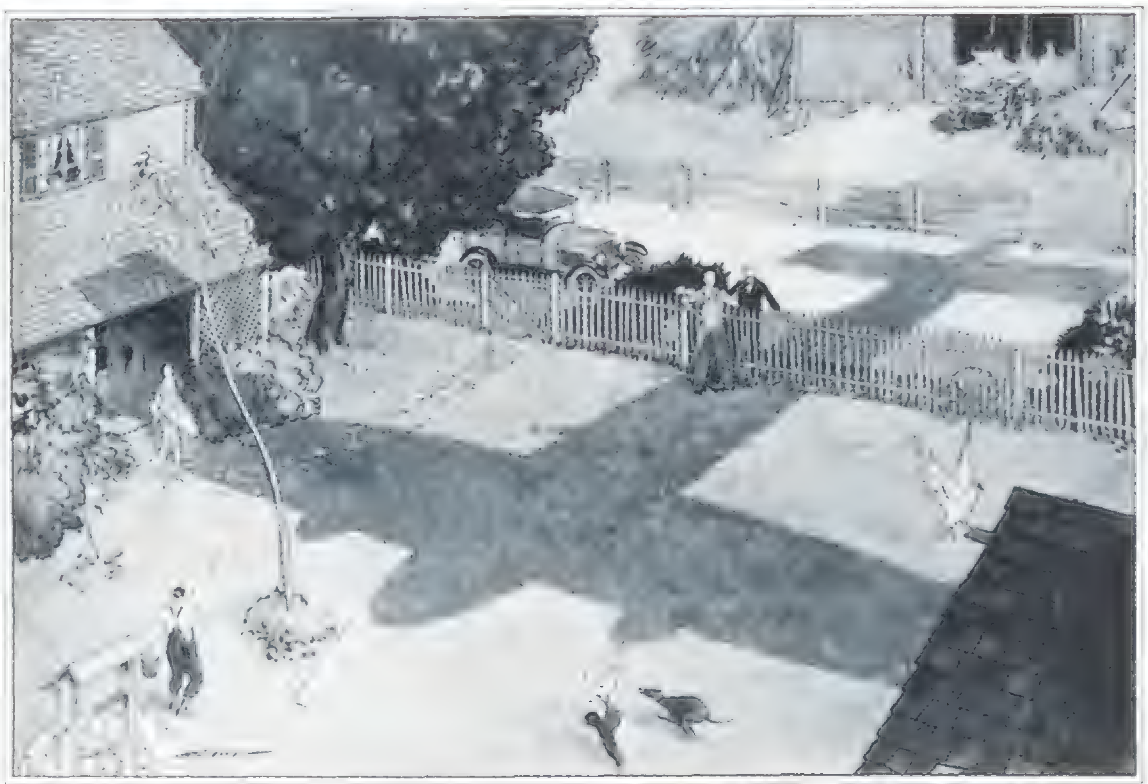
Because Ford knew that safety was the key to the public's acceptance of commercial flight, the Tri-motor was designed with an "extra" engine. As one advertisement boasted, "What if a motor fails? With two, the plane can continue to its destination! If two fail, the remaining motor can extend the angle of descent to cover an area almost half the size of Delaware."

TIRELESS WINGS

Ford found customers for his aircraft in the dozens of small aviation companies that sprang up across the country in the 1920s. Boeing Air Transport, National Air Transport, Pacific, and Varney were all founded in 1926 and 1927. In 1931 they would merge as United Air Lines. Ten other startups from the period would form American Airlines in 1934. Juan Trippe launched Pan American in 1927, the year after Northwest Airlines took to the skies, and by 1929 Transcontinental Air Transport (later to become TWA) was experimenting with a train-plane combination service that cut cross-country travel time dramatically. Many of these companies built their businesses with the Ford Tri-motor.

Although Ford had no trouble convincing the infant airlines of the excellence of the Tri-motor, he knew that ordinary people would have to start considering air travel a normal and necessary part of their lives if the

HARBORS AND PHANTOM PORTS



LIFT UP YOUR EYES!

Perhaps the most significant thing in the great accomplishment of young Colonel Lindbergh is that in him the world sees *the first outstanding example of a generation that is born air-conscious!* Just as the past generation was born to steam, accepting railway transportation as an accomplished fact—and just as the present generation has accepted the automobile as a customary vehicle—so does the rising generation lift up its eyes to the skies!

airlines were to flourish and buy more Tri-motors. He took the problem to the N.W. Ayer advertising agency. Ayer was the agency responsible for inventing the "coffee break" for the Joint Coffee Trade Publicity Committee and for coining several now-famous advertising slogans: "When it rains, it pours" for Morton Salt and "I'd walk a mile for a Camel" for R.J. Reynolds Tobacco. Ayer's management gave the monumental task of salesmanship to seasoned copywriter William "Cap" Anderson. Like other copywriters of the time, Anderson was a novelist, hired for his writing talent rather than his marketing skills. Working with Stout, he created a campaign unlike anything the reading public had ever seen before.

Because nobody (including Anderson, Stout, or Ford) really knew what commercial aviation was going to be like, much of the campaign came directly from Anderson's imagination, which today seems clairvoyant. Foreshadowing the television campaigns of express mail competitors, one ad declares, "When the Chief Engineer turns apoplectic at a telegram from Dallas saying the power plant must shut down until a small part can be sent from the factory, and his secretary promptly suggests, 'Why don't we send one tonight by Air Mail?'... Then you will know that Aviation is an accepted tool of industry!"

The series of 17 advertisements featured arresting, carefully detailed illustrations. These were paired with upbeat copy that combined Anderson and Stout's prescient assumptions with a great deal of romance and a few hard facts. The first ad, "Lift Up Your Eyes" (left), set the tone for the series. Sixty-five years later, it's easy to see why Julian Watkins included this masterfully effective message in his book *The 100 Greatest Advertisements.* The lyrical copy is filled with such a sense of adventure that taking a train instead of flying must have seemed stodgy, and almost unpatriotic. The ads that followed, deftly seasoned with frequent reminders of the dependability of Ford Tri-motors, assured readers of

Truth in Advertising?

The imaginary experience of flight in a Ford Tri-motor was far superior to the real one. Compare the description created by N.W. Ayer's copywriter to that recorded in *Ernest K. Gann's Flying Circus!* Here is Madison Avenue's version, published under the heading "First Flight":

You settle back in your wicker chair a little nervously as the engines roar. Then a burst of speed across the flying-field! Forty miles an hour...fifty-five! Someone shouts: "Watch the wheels!"

Unless your eyes are fixed on the great balloon tires no sense perception tells when you have left the earth. There is only an astonishing feeling of stability; then comfortable relaxation as the motors are throttled down. The giant, tri-motored car moves upward on a cushioning ramp of air....

Gradually you experience a sensation that is certainly one of the most extraordinary man has ever felt. You are transcending human nature. You feel immeasurably superior to the crawling beings in the miniature world immersed in silence two thousand feet below. Though ordinarily you may suffer from fear of heights, this fear does not touch you now, *for there are no lines of perspective drawing you earthward!*....

...The air of other-worldliness that hangs over the earth below is emphasized by the fact that you are hardly aware of forward motion, *though moving twice as fast as the fastest express trains,* and it is as easy to stand poised on one foot in the cabin as on the floor of your own bedroom. Your fellow passengers move freely about, shifting the ten wicker chairs companionably, to play cards, to typewrite, to make sketches, or, gather in groups, first on one side of the plane, then on the other, to study the panorama below.

Ernest Gann remembered the experience this way:

Life with and aboard the tri-motored Fords was far from ideal.... Ford passenger cabins were always too hot or too cold and decibel level assured them a top place among the world's noisiest aircraft. Immediately on boarding, passengers were offered chewing gum which would allegedly ease the pressure changes on their eardrums during climb and descent, but it was just as much to encourage a cud-chewing state of nerves. They were also offered cotton which wise passengers stuffed in their ears so they would be able to hear ordinary conversation once they were again on the ground....

In the first Fords there were no seat belts. Only hand grips were provided to stabilize passengers, and summertime flying could become a purgatory. While they bounced around in low-altitude turbulence the passengers muttered about "air pockets" and a high percentage became airsick. Even with a few windows open the cabin atmosphere developed a sourness which only time and scrubbing could remove.

If the passengers retreated to the lavatory they found little comfort at any season. In winter the expedition became a trial-by-refrigeration since the toilet consisted of an ordinary seat with cover. Once the cover was raised for whatever purpose there was revealed a bombardier's direct view of the passing landscape several thousand feet below.

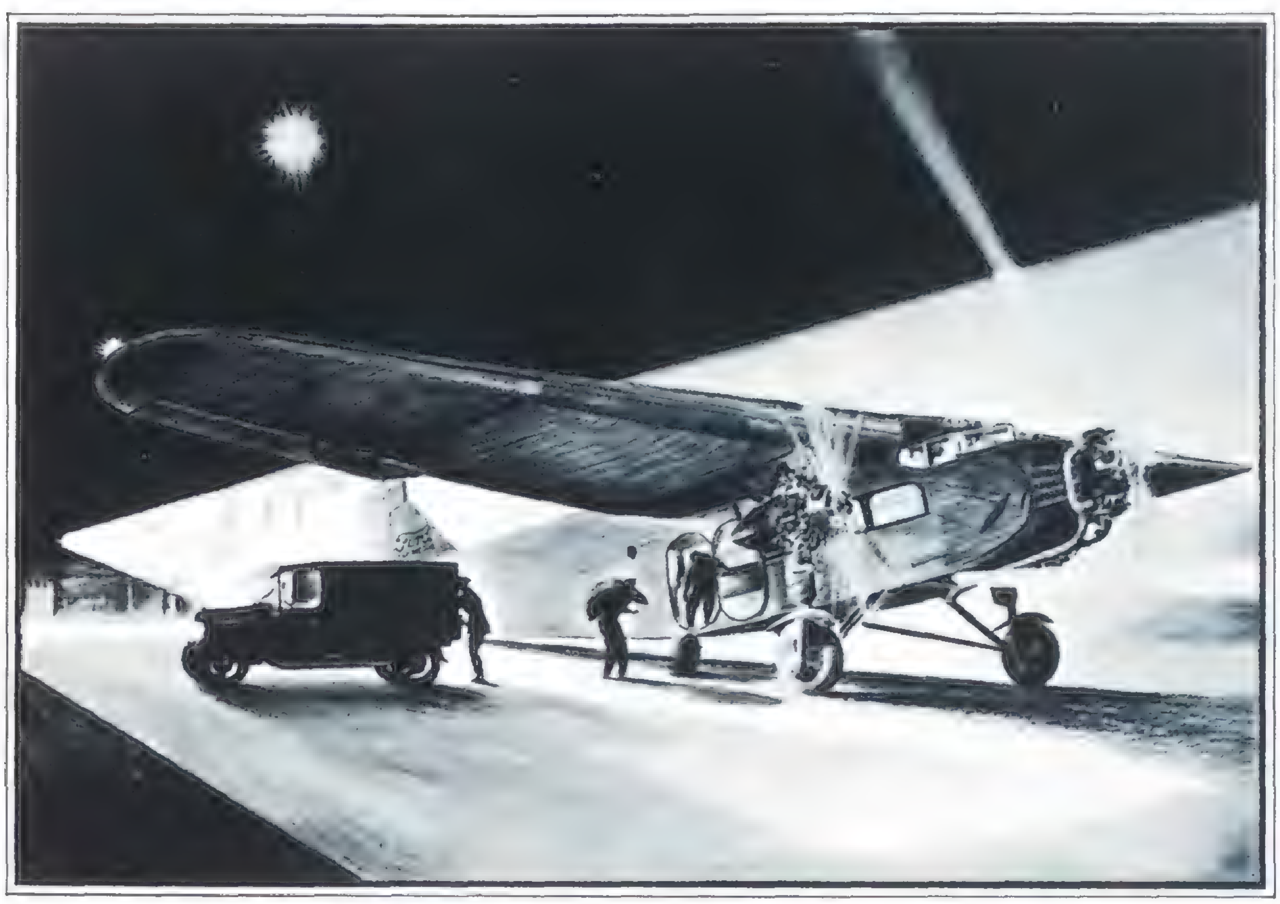
the safety of flying in a tone of voice that made the novel proposal of everyday commercial flight seem eminently reasonable. The fact that the "speaker" was the highly respected Ford Motor Company gave the idea further credibility.

But even if the advertising persuaded the public to fly, the facilities to accommodate increased air travel simply did not exist. Most of the country's landing fields at that time were primitive and ill equipped, some nothing more than cleared fields. Even some of the largest cities could not safely handle the air traffic Ford envisioned. So the campaign targeted two audiences: prospective passengers and city planners. The ads told the nation of the reliability, the benefits, and the sheer joy of commercial air travel. They also stressed its necessity in order to encourage municipalities to make major capital investments in improving airports or constructing new ones.

JENNY PASSES

Ayer scheduled the campaign to run in *American Boy, Literary Digest, National Geographic, Review of Reviews, Saturday Evening Post, Sportsman, Spur, Town & Country, Vanity Fair,* and *World's Work.* The combined circulation of these magazines was 6,150,912. With "pass along" value added, the total number of people reached by each ad rose to 20 million. The campaign ran for 18 months.

In 1928, the first year the ads appeared, Ford sold 39 Tri-motors; the following year the company sold 89. During the period of the campaign, ticket sales for U.S. scheduled airlines almost tripled. Equally important, cities across the country quickly approved the investments necessary to make the dream of commercial flight a reality.



STAMPED AND DELIVERED—5c

Noting the country's swift reaction to the campaign, *The Aero Digest* observed in 1928 that "Ford's advertising has done more to popularize flying among the reading public than all the stunts that have ever been stunted." Ford achieved these remarkable results with an advertising budget of less than $500,000—about $4 million today, but still a bargain compared with the $734 million airlines spent on U.S. advertising in 1990. The fact that the allure of flight created by the campaign did not match the reality makes Ford's success all the more remarkable (see "Truth in Advertising?" p. 65). When air travel finally became as comfortable and routine as the ads predicted, Ford was no longer in the picture. By 1932, the Ford Motor Company had lost $5,600,000 on its aviation enterprises, according to historian William Leary. At the end of that year, Ford closed his airplane factory.

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Endeavour

SAVING INTELSAT VI

A satellite is stranded in a useless orbit, and only the space shuttle can rescue it.

by Greg Freiherr

Hoping to save money, managers at Intelsat decided in late 1989 not to insure a spacecraft soon to be added to their family of communications satellites. On March 14, 1990, they wished they had.

After a flawless launch atop a Titan 3 rocket, the $150 million Intelsat VI satellite was suddenly in jeopardy. Following second-stage shutdown, explosive bolts should have fired, separating the rocket from the payload and its kick motor—the engine that would have sent the satellite to geosynchronous orbit 22,400 miles above Earth. But there was no explosion. Technicians at Martin Marietta had incorrectly wired the Titan's payload release mechanism.

"Everything we were hearing was 'Good launch.' Everything was great but we were blind—we were waiting for the data," says Frank J. Scalici, who served as flight coordinator for Intelsat during the launch. "But when it didn't get to the Earth station on time, then the 'Oh shit!' mentality took over."

Intelsat's ground controllers ordered an electronic sweep of the region where they thought the vehicle should be, looking for signals from the wayward satellite. When they couldn't find any, they gradually increased the size of the search area. Finally they decided to call in NORAD, the Department of Defense's radar facility for tracking objects in orbit. After three hours of searching, NORAD detected the satellite, dubbed F-3, drifting in an orbit only 200 miles above Earth, far too low to relay telephone calls and three color television channels for countries in North and South America, Europe, and Africa.

That wasn't the worst of it. "It was obvious to us that with the increased drag from the Titan upper stage, the satellite was going to get sucked back into the atmosphere," Scalici says. "It was only a matter of hours."

Controllers decided they had to jettison the Titan upper stage, even though that meant losing the satellite's kick motor, which was bolted to the Titan. F-3 was saved, but in the process it was imprisoned in an orbit more than 22,000 miles too low. Because Intelsat had decided against spending $50 million to insure the launch, it now risked losing a $250 million investment—$150 million for the satellite and over $100 million for the launch. David Tudge, Intelsat's deputy director general of service and administration, defends the decision not to insure: "The insurance market had gone from premiums that were very low—unrealistically low—up to ones nearly touching 30 percent. As far as Intelsat is concerned, we will take out insurance if the commercial rate is a fair reflection of the risk. And we judged at [that] time, with market rates in the order of 20 percent, that the risk was less than that."

Intelsat, an international consortium of 121 mostly government-owned telephone companies, had two options for saving F-3. It could attach a new kick motor and boost the satellite to its proper orbit, or bring it back to Earth for another launch. Both required the space shuttle. The reboost option was considered both easier and more economical. "If you brought the satellite back to Earth, you'd have to spend another $100 million-plus [in addition to $100 million for retrieval costs] to start the whole process all over again and relaunch," says John Hampton, acting director general of Intelsat. "And the riskiest part of a launch process is getting it up to the place where it is now. So looking at all the technical elements, there was enough confidence that a reboost from orbit is very doable, very achievable, and it is most cost-effective."

This spring, Intelsat is scheduled to find out for sure.

The rescue mission, one of the riskiest NASA has ever attempted, will be the first active rendezvous by the shuttle. The shuttle and the satellite will simultaneously maneuver toward a single point while whizzing around Earth at a speed of 17,000 mph. The rescue, which involves the first in-orbit attachment of a live rocket motor, will be the shuttle *Endeavour*'s first mission.

Fortunately for Intelsat, NASA has decades of experience in orbital encounters. In fact, satellite rescues became almost commonplace during the mid-1980s. The first satellite to be repaired in orbit was Solar Max, which shuttle astronauts fixed in June 1984. Later that year, two communications satellites—Palapa B2 and Westar 6—were picked up and returned to Earth on a single mission. And in 1985, astronauts repaired Leasat 3, a commercial satellite the U.S. Navy had leased from Hughes Communications.

This spring's mission will make Intelsat, which is paying nearly $150 million to save its satellite, a partner in the

Wielding a capture bar, astronaut Pierre Thuot will attempt to snare Intelsat's wayward satellite.

rescue. The consortium has dug into a reserve fund to cover launch failures, sending $92 million to NASA specifically for the rescue and $43 million to Hughes for a new kick motor. Intelsat has also coughed up an additional $9 million for design and consulting costs.

But if the consortium had its way, it wouldn't pay one cent toward the rescue of F-3. Shortly after the failure, Intelsat filed a suit seeking financial compensation from Martin Marietta, which had launched the satellite on its Titan 3 booster. The case was dismissed at the end of 1991, but Intelsat filed an appeal earlier this year. Though the wiring error was committed by Martin Marietta, that company feels the only thing it owes Intelsat is a relaunch at a fee specified in the original launch contract. "The original [case] was thrown out of court because they couldn't prove it was malicious," says Intelsat's Scalici. "It was a 'buyer beware' kind of thing.

"The interesting thing," continues Scalici, "is that we found out after the failure that CT3 [the next commercial Titan launch] had been wired the same way, which is what our next Intelsat VI was on." To everyone's relief, the duplication in wiring was detected before that launch.

But Intelsat will not have to pick up the entire cost of the rescue. NASA is kicking in $4 million because it believes the mission will provide an opportunity to practice extravehicular activity—experience that the space agency wants to apply toward the development of a space station. In fact, a day after the planned satellite rescue, two other astronauts, Kathryn Thornton and Thomas Akers, will spacewalk to test methods for constructing the station, and the day after that two more astronauts will venture outside the shuttle.

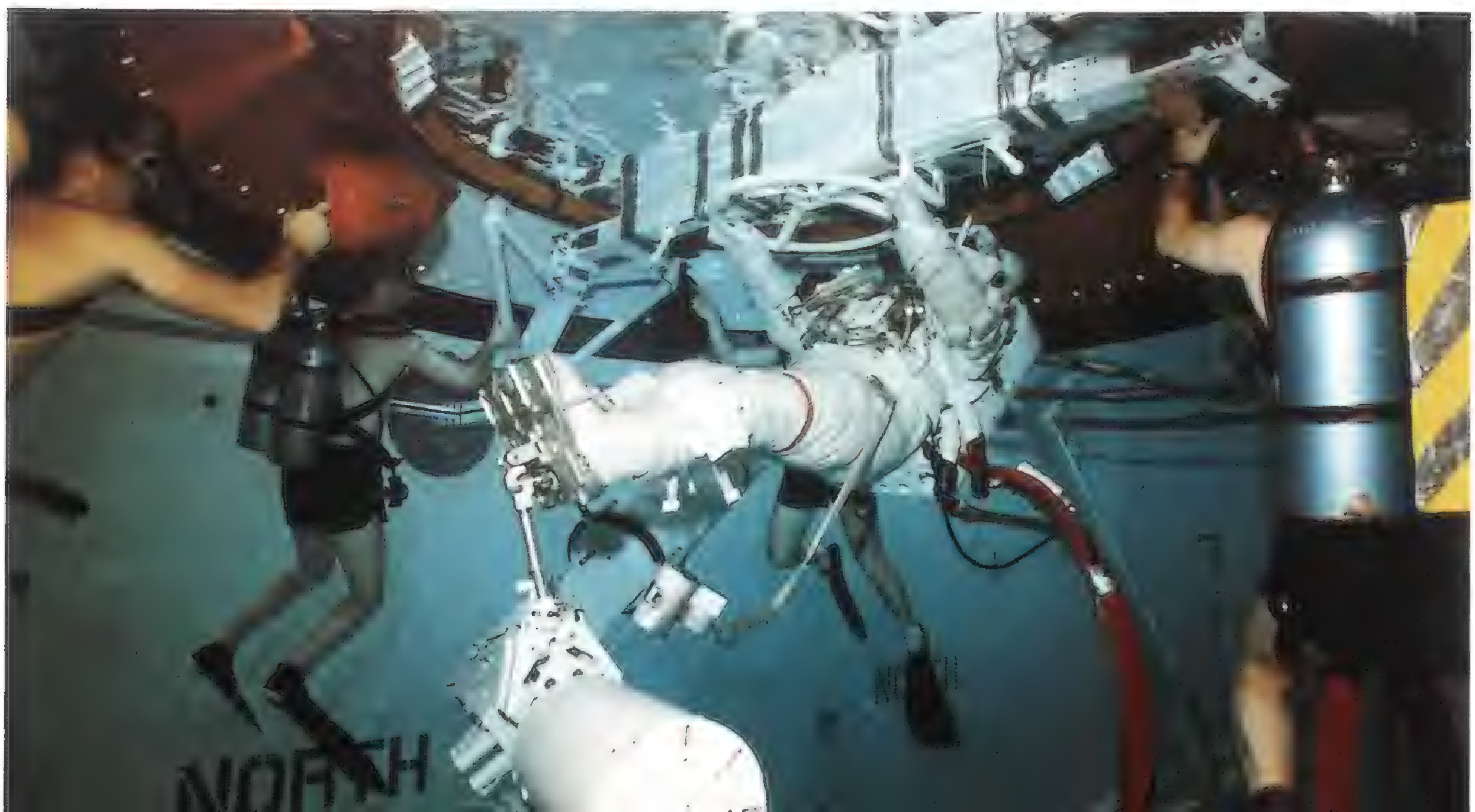
"NASA has an obligation because we have this national asset," says Pat McCracken, NASA's mission coordinator for the rescue. "And we have this capability, and to say no to someone is difficult." McCracken asserts that NASA's role is more than just a public relations effort. "You can generate just so much good PR, then you have to go out and do something about it, and I think this is one instance where we actually can."

Intelsat's controllers will be responsible for meeting the shuttle halfway, bringing F-3 down to an orbit within reach of the shuttle. The control room staff already has experience in maneuvering the satellite: after determining that the initial 200-mile orbit was rife with dangers, including debris and atomic oxygen—both of which can scar the surface of solar cells and reduce their potential to generate electricity—controllers raised the satellite to 300 miles with attitude jets designed to keep it stable in geosynchronous orbit. Those jets will be called on again to maneuver F-3 back down to meet the shuttle—but only after *Endeavour* is safely in orbit and its systems are checked out. The rendezvous would certainly be simpler if the satellite were brought down and stabilized in a lower orbit several days or even weeks earlier. Then the shuttle could aim at the satellite, timing its launch and the inclination of its trajectory as it did for its previous rescue missions.

But Intelsat does not want to do that. "If we knew exactly how many days from the time we move the satellite to when the shuttle would lift off, we could do it, but clearly shuttle launches get delayed," says Leonard Dest, Intelsat's engineering manager for hardware implementation on the reboost mission. "And if there is a delay, the satellite would be exposed to atomic oxygen."

As a result, *Endeavour* and the communications satellite will be zeroing in on a "control box," a volume of orbital space that extends between 222 and 233 miles above Earth. "Orbital mechanics is amazing stuff," says shuttle commander Daniel Brandenstein. "To

To adjust to weightlessness, Thuot rehearses each step of the rescue in an underwater tank.



catch up to a satellite that's ahead of me, I turn around and burn the engine to slow down. This lowers my orbit, but it gives me a faster angular rate around the Earth, so I can catch up."

The program for each burn of the shuttle's engines is sent up to its computers from Johnson Space Center in Houston. Brandenstein manually handles the smaller burns of the shuttle's reaction control system—the small jets that keep the shuttle oriented in space. When the orbiter maneuvering system engines are fired, the computer takes over, but Brandenstein can abort the firing by not pushing the button that gives the computer the go-ahead.

Once the shuttle is in the control box and the satellite is in view, Brandenstein will use the reaction control jets to snuggle the shuttle to within 35 feet, close enough for the orbiter's mechanical arm to reach F-3. During the delicate maneuvers, Brandenstein will have to avoid hitting the satellite with the shuttle's exhaust plumes, which would send the satellite into a tumble. When *Endeavour* and F-3 are in close formation, Brandenstein will put the orbiter into a free drift by shutting down all the systems that control maneuvering. (The idea is to prevent any engines or jets from inadvertently firing and overstressing the shuttle arm.)

Pierre Thuot will ride the shuttle arm and make the grab, but Bruce Melnick, the arm operator, will have to get him there first. Melnick has had some near-Earth experience similar to what he will be doing in space. As a helicopter pilot in the U.S. Coast Guard, he helped save passengers from a cruise liner sinking in the Gulf of Alaska in 1981. Melnick and his crew plucked 115 of the 522 passengers out of lifeboats pitching on 12- to 15-foot seas with 18-mph winds.

"The way we fly Coast Guard rescue missions," explains Melnick, "is that we have a hoist in the back that is not visual to the pilot, and the hoist operator 'cons' [talks] you in so the basket gets to where it is supposed to go. You're relying solely on the eyes of the hoist operator."

In space, Melnick will be maneuvering Thuot into striking distance of the satellite. Initially, Melnick will guide his movements by looking out the back of the shuttle cockpit, where the arm controls are located, and by watching an image from a television camera mounted on the end of the arm. Thuot, whose feet will be strapped onto a platform attached to the arm, will be facing away from the satellite. As the arm approaches the target, Melnick will rotate Thuot so he can see F-3 and talk Melnick in. "So it will almost be like I'm back flying a helicopter and Pierre is conning me in. If he says, 'Move me a little bit closer,' all I have to do is push in on the hand controller and the arm's computers are smart enough to drive me directly in to where he wants to go," Melnick says. "If he says, 'Rotate me back a little bit,' I just rock him back. So it's like I've been there before."

Thuot, Rick Hieb, and Bruce Melnick sharpened their rescue skills by practicing on a near-duplicate of F-3.

Things might get dicey if the satellite and the shuttle are not perfectly—exactly—aligned. If the satellite is moving just a few inches per minute off course, there could be a problem. So Melnick wants to make the capture within five minutes after Brandenstein puts the shuttle into a free drift.

But what if the shuttle arm doesn't work? Then Thuot will have to strap his feet onto the edge of the payload bay so Brandenstein can fly him right up next to the satellite. "Hopefully we won't get to that point, but I feel that the vehicle has good enough control to do it," says Brandenstein. "Of course, if anything gets squirrelly, obviously we're not going to jeopardize Pierre and squash him in between the two."

Before Melnick can snare the satellite with the arm, Thuot will have to stop the 8,960-pound satellite from rotating without damaging the solar cells that cover its exterior. To do this, Thuot will use a 12.5-foot "capture bar," a metal beam with spring-loaded latches that can grab the satellite. The capture bar's latches will fire automatically when triggers on either side of the device make contact with pads on the end of the satellite. To help Thuot, Intelsat controllers will spin the satellite down to about half a rotation per minute to keep it from tumbling. If all goes right, Thuot will use a large wheel mounted to the capture bar to stop the spin of the satellite. But rescue missions don't always go as planned.

"There's a temptation to think that you can predict precisely how the vehicle is going to be when you get there, but it doesn't always happen that way," says Joe Engle, a former X-15 pilot who commanded the Leasat rescue. On that mission astronauts had a hard time handling the satellite. Instead of spinning, it was slowly tumbling. The original plan for grappling the satellite failed, and the crew had to improvise by grabbing the satellite by hand and forcing the capture bar into place. F-3's rescuers, however, will probably not face that predicament. "Intelsat is alive and well," says Engle. "They can monitor and change the attitude and spin rate, whereas Leasat was essentially dead."

But Thuot and NASA must still play the "what if" game. Though the satellite itself is healthy, a problem could arise with the capture bar. If the bar's automatic mechanism fails, Thuot can manually trigger the latches. And if the bar fires inadvertently or at the wrong time, he can manually recock the mechanism and try again.

Once Thuot has the satellite floating motionless in space, he will let go so that Melnick can grab a fixture on the capture bar with the robot arm, then pull the satellite into the cargo bay. Thuot will go along for the ride, and once he is inside the orbiter bay he will dismount from the arm. He and Rick Hieb will then begin the process of mating the satellite to a new kick motor.

Once everything is in place, the satellite and its motor will be released from

the shuttle bay using SuperZip, a spring system for propelling the satellite outward. The shuttle will probably be out of the way when Intelsat's controllers begin to fire the new kick motor, but if the two vehicles somehow end up in the same area, the shuttle will simply position its heat-resistant-tiled belly toward the satellite to shield itself from the exhaust.

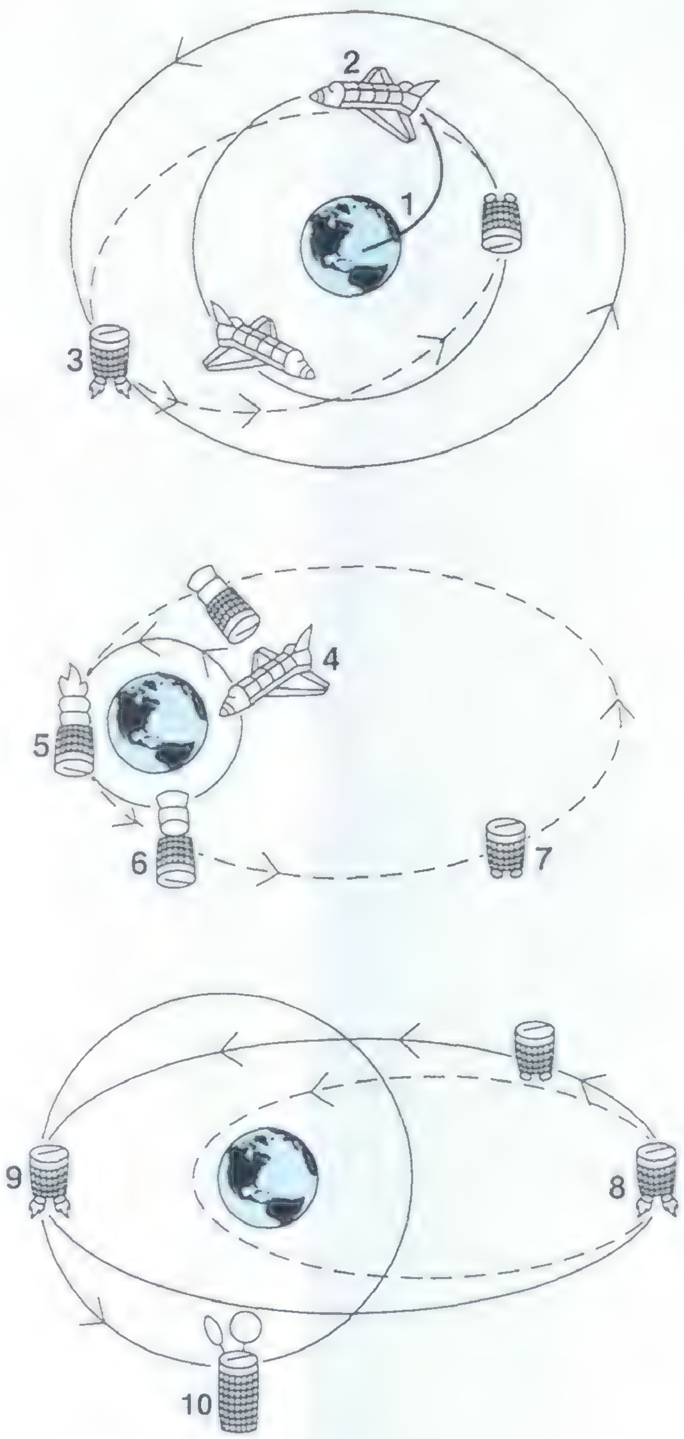
One of NASA's biggest worries is that SuperZip will fail. If it does, the astronauts would have no choice but to jettison the cradle—the device that will hold F-3 in the cargo bay. Although the payload doors can close on the kick motor alone, they cannot close when the satellite and motor are joined. And without the doors closed, the shuttle cannot return to Earth.

There is a lot of pressure to succeed, "not just from the space station point of view," says Jerry Lowe, a NASA payload specialist, "but from an overall shuttle point of view to demonstrate again that there are some useful facets to the shuttle other than just putting certain payloads in orbit."

"Your highest anxiety is doing the job right," says astronaut Hieb. "People have invested typically several hundred million dollars in the flight and entrusted you with their precious baby. So it's a matter of tremendous professional pride to do everything just right

The Rescue

Both the shuttle and F-3 are moving counterclockwise. (1) The shuttle lifts off. (2) The orbital maneuvering system fires to put the shuttle into a 200-mile orbit. (3) Intelsat controllers begin the first of four burns to move F-3 out of its 300-mile orbit and into a transfer orbit that overlaps with the shuttle's orbit. (4) The shuttle and F-3 rendezvous. Astronauts attach the new kick motor, then release F-3. (5) The kick motor fires, sending F-3 into a transfer orbit. (6) The motor separates from F-3. (7) F-3 is reoriented. (8) F-3 begins a series of burns to put it into a second transfer orbit. (9) Controllers fire F-3's thrusters to put the satellite into geosynchronous orbit. (10) Controllers de-spin the satellite and deploy the antennas.



JIM MATISON/INTELSAT

From their post in Washington, D.C., Intelsat controllers will direct F-3 to an orbit within Endeavour*'s reach.*

so you don't make a single mistake." Says NASA's McCracken: "We always plan to be successful. If we didn't think we could do it, we wouldn't do it." Apparently Intelsat agrees, since only eight of its 121 members have taken out insurance on the rescue, paying $13 million for $44 million of coverage.

For now all is quiet. F-3 is in hibernation, consuming just enough power to maintain its temperature against the cold of space. All of its telecommunications equipment has been switched off to preserve its 12 years of operating time. Though Intelsat controllers check in with the wayward satellite six times a day, all they can really do is wait for NASA to do its thing.

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Birdmen Come to Cleveland

They became the nation's most powerful aerospace contractors, but 75 years ago, four young men worked side by side in an Ohio plant cobbling together the first American warplanes.

by Frank Kuznik

The factory disappeared long ago, swallowed up by ever-larger manufacturing plants that today sprawl across northeast Cleveland. The only remnant that evokes the aviation history made at 16800 St. Clair Avenue is a pair of nearby side streets—smidgens of streets, really, barely bigger than alleys—named "Plane" and "Glen."

They seem a paltry legacy of the Glenn L. Martin Company, an airplane manufacturer that became a major industrial presence in Cleveland in the years after World War I. Within 10 years it was one of the biggest producers of aircraft for the U.S. Navy. But what really distinguished the plant from the innumerable other aircraft companies that sprang up in the same period was the all-star team of aviation pioneers who for a few years worked there side by side.

Glenn Martin's somber mien seems to have permeated this 1919 corporate portrait, in which Larry Bell, test pilot Eric Springer, Martin, and Donald Douglas (left to right) pose in front of the first Martin bomber. Before coming to Cleveland, Martin built and flew some of the earliest airplanes, such as the 1912 Curtiss-like pusher shown above.

NASM (2)

Glenn Martin himself, a contemporary of Glenn Curtiss and the Wright brothers, was an inventor and entrepreneur who parlayed his fame as a daredevil pilot into financing for a business that would eventually become the Martin Marietta Corporation. The number-two man at his shop in Cleveland was Larry Bell, who went on to found Bell Aircraft, the company that helped pioneer the development of the helicopter and built the X-1, the first airplane to fly Mach 1. Martin's chief engineer was Donald Douglas, who subsequently formed the Douglas Aircraft Company, the producer of the famous DC line of airliners and now part of McDonnell Douglas. Working with Douglas as chief draftsman was James H. "Dutch" Kindelberger, who later became president of North American Aviation, the company that evolved into Rockwell International. Though little has been written about the Martin company in Cleveland, the plant was in fact a crucible that helped forge half the nation's aerospace industry.

Fortunately, there are still a few living eyewitnesses to those critical years. One of them, Fred Crawford, was a recent graduate of Harvard when the Martin company set up shop in Cleveland, and though he didn't work for Martin directly, his job often brought him in contact with the people there. Like the young men at the plant, Crawford went on to play a substantial role in the business of aviation, taking the helm of the company that eventually merged with another to became TRW. Now 101, Crawford recently sat in his study overlooking Lake Erie and recalled with remarkable clarity the men of the Glenn L. Martin Company of Cleveland, Ohio.

In the summer of 1917, Martin was an entrepreneur in need of a fresh start. A merger with Orville Wright 10 months earlier had soured, and Martin had had to shut down his aircraft plant in Los Angeles. Histories of the era recount that at this juncture in his career, Martin was wooed to Cleveland by Alva Bradley, the wealthy owner of the Cleveland Indians baseball team. But according to Crawford, it wasn't Bradley who snagged Martin. It was a maverick industrialist and aviation buff named Charlie Thompson.

Thompson owned Steel Products, a small company that manufactured engine parts, and Crawford had been hired as his assistant. "Charlie Thompson had decided that airplanes were the coming thing," recalls Crawford, "so we had bought a cow pasture out in east Cleveland and built a hangar—it wasn't very big, but it was a hangar. But nobody in Cleveland knew a goddamned thing about airplanes. So my boss called Glenn Martin, who was out of work at the time, and said he'd like to have him come to town so they could talk.

"One day he said to me, 'Get in the car, we're going to

The Cleveland factory's first product was the MB-1 bomber. The 1918 Armistice dimmed Martin's hopes for that model.


NASM

WESTERN RESERVE HISTORICAL SOCIETY (2)

At 101, Fred Crawford still vividly remembers the men of the Martin company. Long a devotee of vintage automobiles, such as the 1912 Buick he's driving in the above circa-1944 photo, Crawford became president of an engine parts company that evolved into the aerospace giant TRW.

meet an interesting man.' We got in the car, an old Winton—with a Victoria top, of all things—and went down to the station and Glenn Martin got off the train. I can see him now, big tall serious fella, skinny, with glasses."

It's easy to see why Martin made such a vivid impression on Crawford. One Cleveland newspaper described him this way: "He has an exceptionally wide forehead, the sort sometimes called bulging. Heavy black hair and tortoiseshell eyeglasses add to the effect. His fingers are long and slender, the fingers of the dreamer...dextrous and skillful-looking." A lifelong bachelor who lived with his mother, the somber Martin abstained from liquor, tobacco, and even coffee.

The day Martin first visited Cleveland, says Crawford, "we drove out to the Mayfield Country Club and had lunch on the porch and propositioned Martin to come and run this plant. He was interested, but he said he had to go home to arrange his affairs and get his mother." In the ensuing weeks, Thompson proceeded to line up local investors, who pitched in $2.5 million in financing. The nascent company, with Thompson installed as president and Martin as vice president, was soon gearing up for business. By the spring of 1918, the cow pasture with the tiny hangar had been transformed into a 71-acre flying field with a 61,000-square-foot factory. Martin's arrival whipped up considerable local excitement, with newspaper headlines announcing "Gigantic Aeroplane Company is Formed to Build Plant Here" and "Birdman Comes to Show Clevelanders How to Fly."

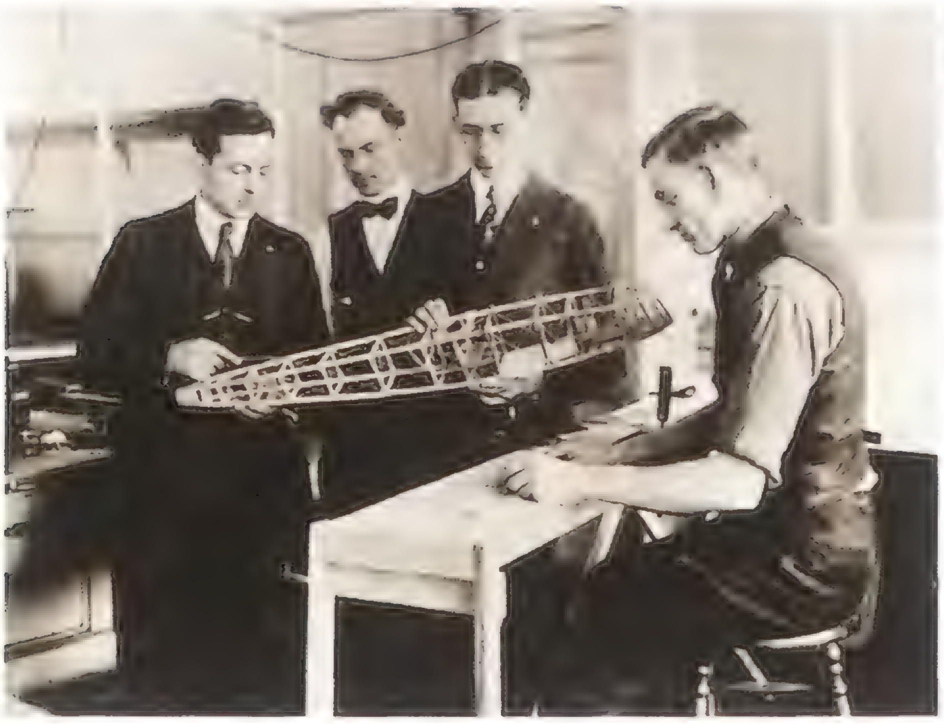
About 30 men who had worked for Martin in Los Angeles came with their former boss. Among them was Larry Bell, who had joined Martin in 1912. Crawford, who used to visit the Martin plant as an emissary for Thompson and the other investors, remembers Bell as a "little fella" in his mid-20s, personable and a bit naive. "He was a country boy, unsophisticated," Crawford says. "When Martin offered him the job as plant superintendent he knew he'd have to entertain, and had been told that when he met a man he should buy him a drink. But he didn't know the difference between wine and whiskey. So he bought a bottle of something that was not quite liquor, some sort of crème something, and lugged that around for fear he'd have to entertain somebody."

Dutch Kindelberger, a self-taught engineer, joined the Martin company straight out of the Army. According to *Larry*, a Bell biography written by Donald Norton, in his first two weeks on the job Kindelberger invariably showed up for work wearing his fatigues. When Bell kidded him about it, Kindelberger declared, "Plenty of wear left in these." Crawford remembers Kindelberger as a "breezy young fellow, full of fun" who retained his sense of humor well into adulthood. "Kindelberger and [Boeing president] Bill Allen became good friends, and one time they were dining in New York together at [the New York restaurant] 21," Crawford says. "Well, the people at 21 didn't like pansies—what do you call 'em now, gays? So Kindelberger and Allen said, 'Let's have some fun.' They sat at the table and put their arms around each other and fussed around until I guess they almost got thrown out."

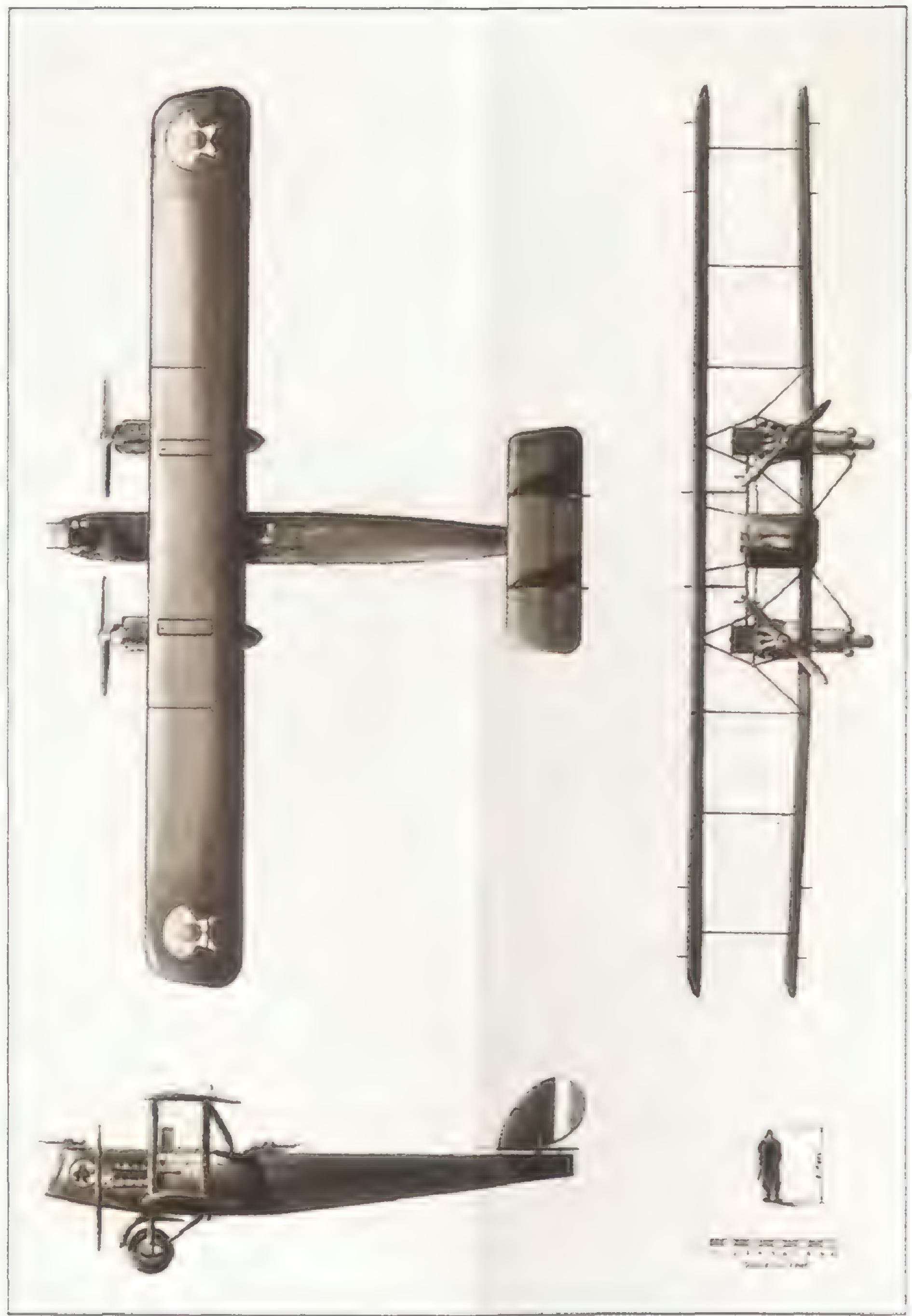
Donald Douglas had already been in and out of the Martin fold once. When he had answered Martin's initial summons and arrived in California in 1915 shortly after graduating from college, he was 23 and looked so young that he took Martin by surprise at their first meeting. "I think he had the idea that anyone who came out of school, from MIT, would have a long beard," Douglas remarked later. The young engineer was equally dumbfounded to find himself in a company where the standard method of stress testing was for Martin to climb into an airplane and jump up and down to see if anything broke. Douglas had been with Martin only a year when a company backer insisted on replacing him with his own engineer. He got a job as chief civilian engineer in the Army Signal Corps in Washington, but he soon grew frustrated in the bureaucratic confines of gov-

ernment. When Martin wrote in 1917 inviting Douglas to Cleveland, the young man promptly rejoined him.

From the start, the investors that Charlie Thompson had assembled to back Martin were at odds with their celebrity hire. "Martin never did get on with them over what to build and things like that," says Crawford. "He was a difficult fellow to handle, a one-man operator who chafed under any kind of control. He began fooling around with a small airplane he thought Uncle Sam would use as a training plane. But by this time the war was on, and the stockholders thought



Douglas (left), Martin (second from right), and two unidentified workers contemplate an MB-1 model.



Though the MB-2 was Martin's creation, a competitor soon won the contract to produce the improved bomber.

we ought to build military stuff. So they got him working on the Martin bomber."

Martin's caution was well advised: the government had already declared that all wartime aircraft production was going to be handled by the automobile companies, which had made extravagant promises to deliver 100,000 airplanes in two years. But in January 1918 Martin managed to win a contract to produce six bombers for the Army, and before his factory was even completed, his staff set to work.

Martin's ideas were unveiled that August. The MB-1, the first warplane designed and built in the United States, was a craft well ahead of its time: a three-man fighter-bomber with two 400-horsepower Liberty engines, a then-astounding wingspan of 72 feet, a half-ton load capacity, and a maximum speed of 105 mph. In October the Army ordered 50, and within a few weeks, nine were ready for delivery.

But on November 11 the war came to an end. Two days later the Army cut its order to 10, and the next day to four. Martin was able to stay in business by hustling government orders for a handful of MB-1 variations—six were turned into mail planes—but a year later the company took another blow: the Cleveland backers decided they wanted out.

Virtually every written account of the breakup repeats the explanation offered in *Box Kites to Bombers,* the official history of the Martin company: "The Cleveland financiers who had backed The Glenn L. Martin Company for patriotic reasons during the war failed to see the future. They wanted to liquidate the company." According to Fred Crawford, however, it was mostly Martin's idiosyncrasies that led to the split. "Martin had been researching airport problems and became convinced that we didn't need airports—we needed seaplanes, because there are very few cities in the country where there isn't water nearby," he says. "So he began crabbing all the time because he wanted to build seaplanes. Charlie Thompson and his group wanted to go another way, so they decided to separate." Martin agreed to line up new financing and buy out their shares at six percent interest.

"It's too bad," Crawford adds. "If Glenn Martin had been a company man instead of a one-man operator, the Martin company would probably be Cleveland's biggest industry today. And maybe the leading airplane builder, because they were way ahead of the game."

Martin couldn't hold on to his best talent either. Donald Douglas left the company in the spring of 1920. Accounts differ as to why, exactly, he made the break. Douglas himself says he was simply feeling ambitious, eager to strike out on his own. But according to the biography *Larry,* Douglas left because he had gotten into a dispute with Bell over a

Minta Martin accompanied her son everywhere; here, the two visit a new aircraft plant in 1941.

technical point and Martin had refused to back him up. However, in the aerospace history *Barons of the Sky,* author Wayne Biddle says that Bell had in fact considered leaving with Douglas. Biddle suggests that Douglas quit for a number of reasons, in part because he was anxious about the company's financial soundness and in part because, in the words of one industry observer, he "couldn't get along with Glenn."

After moving to California, Douglas managed to put together an aircraft company and win some lucrative military contracts. Half a dozen Martin employees decided to follow him, including, in 1925, Dutch Kindelberger. Both Douglas and Kindelberger appear to have maintained cordial relations with their old employer; when Martin later traveled to California, he paid the two a visit. Back in Cleveland, however, Martin's relations with Bell grew tense. "Everyone who knows what's going on thinks I ought to be company president," Bell once groused to his wife. In late 1924 he gave Martin an ultimatum—either give him part ownership of the company or he would leave. Martin refused, and in 1925 Bell took off.

Perhaps it was inevitable that a group of such driven, headstrong men would spin off in different directions. Douglas, for one, was probably never committed to Martin for the long haul; though he had a wife and two children, in his two years in Cleveland he never bought any furniture, so sure was he that he would soon be leaving. Nonetheless, Crawford says it was Martin's dictatorial manner that ultimately drove the men off. "Martin was not an easy man to deal with; you didn't sit down and reason with him, say: 'Let's try this' or 'Let's try that,' " he recalls. "If he had been a cooperation man, those fellows would have stayed."

Nor does Martin appear to have made many friends outside of work. He joined Cleveland's prestigious Union Club, but aside from playing in chess tournaments—he once went 43 moves against the world champion before losing—he was

When Martin bombers sunk the "unsinkable" Ostfriesland *in 1921, the military was sold on naval aviation.*

basically a recluse, devoting himself to his business and his mother ("Mother and I have always been pals," he once confided to a reporter). When asked about hobbies, he responded, "I used to enjoy hunting coyotes by airplane while out west. Gardening is my present hobby, especially taking care of trees and shrubs."

For all his aloofness, Martin did have a soft spot for anyone who shared his infatuation with flight. Cleveland Model & Supply Company owner Edward Packard, 86, recalls being introduced to Martin as a teenager, when a teacher noticed his interest in airplanes and arranged a field trip to the plant for him and a friend. "Martin was very friendly to us," Packard says. "He said he was glad to see boys getting interested in airplanes. He said, 'Maybe when you get older you can work for us.' I said, 'Yeah, I'd love that.' " A few years later Packard did land a summer job at the Martin plant, and he always found Martin willing to talk. "He seemed to take a liking to me as a kid with aviation design ideas," Packard recalls. "He never turned me down when I asked to see him. It was nice, this famous man and I getting together."

According to a 1920 report in the Cleveland *Sunday News-Leader Magazine,* "In the Glenn L. Martin shops everybody seems to be having a good time—to be getting genuine enjoyment out of his work." To be sure, the local press seemed

intent on flattering the town patron at every possible turn, but even discounting the boosterism, the plant does emerge from newspaper accounts as a fairly decent place to work. In 1919 employees organized a "Martin's Men's Club," which met every Friday night and offered plant workers and their families a lively variety of lectures, concerts, talent shows, dinners, and dances. Martin employees could also take advantage of an at-cost grocery buying service the plant cafeteria operated.

The fortunes of the company picked up considerably in 1920, thanks to Army aeronautics director General Billy Mitchell. Mitchell was a staunch believer in the military supremacy of the airplane, and that summer he rammed through an order for 20 second-generation Martin bombers, the MB-2s. The following year Mitchell gave the MB-2 another boost: to convince the Navy of the efficacy of aerial bombardment, he led a squadron of the bombers out beyond the Virginia coast to target a captured German battleship. The mammoth *Ostfriesland* was considered unsinkable, but after the MB-2s had made three bombing runs, the ship disappeared beneath the waves. Mitchell proved his point, warfare was changed irrevocably, and the Martin company picked up some substantial Navy contracts.

By the summer of 1926 the company employed 800 workers and was gearing up to turn out three aircraft a week. It had just won a $3 million contract for 100 "triple-purpose" Navy airplanes, the first of the TM series designed for observation, torpedo, and bombing runs. Martin was always looking ahead, though, and this time what he saw was that it was time to move on. His factory was no longer big enough.

Over the next year and a half Martin played cat and mouse with the city. He kept negotiating for a favorable lease on a huge tract of land adjacent to the airport being built on the opposite end of town but all the while quietly continued to check out opportunities in other cities. Early in 1928 he announced that he had settled on a site near Baltimore.

When the news broke that Martin was leaving, Cleveland went through a great deal of hand-wringing over what could and should have been done to keep him there. In retrospect, it's clear that all the funding and land the city could offer wouldn't have been enough: Martin had never gotten over his obsession with seaplanes, and what really attracted him to Baltimore was the nearby Chesapeake Bay. "The reason for him moving was 90 percent to be on the water," says Crawford. "Lake Erie froze over then; it wasn't good for seaplanes, and he was determined to build them."

Martin was wrong about the future of seaplanes, of course, and his fixation proved costly. Despite his staff's opposition, he invested heavily in developing and building the famous China Clipper "flying boats" of the 1930s, incurring losses so heavy that they nearly pulled the company under.

Donald Douglas' company continued to prosper, embarking on the DC line of commercial aircraft in 1932. Two years later Dutch Kindelberger left Douglas, soon becoming president of North American Aviation. And Larry Bell, after floundering on his own for several years and then working for Consolidated Aircraft, finally raised the financing to open Bell Aircraft in Buffalo in 1935.

NASM

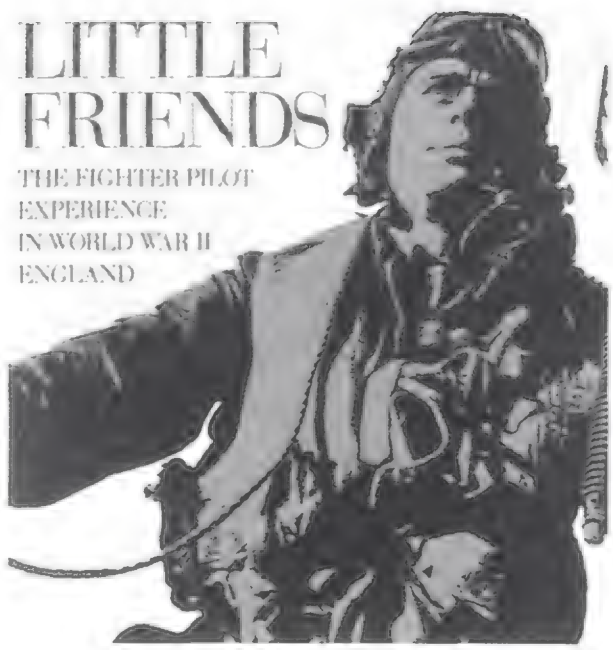
As for the plant in Cleveland, it was sold in 1928 for a reported $1 million to a group of investors from Chicago, who renamed it the Great Lakes Aircraft Corporation and tried to pick up where Martin had left off. They were ultimately unsuccessful, filing for bankruptcy in 1935.

Aviation fever still raged in Cleveland. The city's Nation-

al Air Races were in full swing by then, and daredevils like Roscoe Turner and Jimmy Doolittle were thrilling huge crowds. But that early flicker of brilliance on St. Clair Avenue, ignited when four young men came together to focus their prodigious talent and drive on a common goal, had gone out for good.

Actually a composite of four photos, this image of three Martin bomber squadrons over Dayton, Ohio, was probably produced by the Army to bolster faith in a strong air force.

Little Friends: The Fighter Pilot Experience in World War II England
by Philip Kaplan and Andy Saunders. Random House, 1991. 256 pp., b&w and color photos, $50 (hardbound).



On January 2, 1992, I landed a Cessna 210 at Homestead Air Force Base in south Florida, and as I switched off the engine a tall, lean, white-haired man strode across the tarmac to greet me. He was Colonel Don Blakeslee, legendary leader of the famed Fourth Fighter Group and, in my book, America's greatest fighter pilot and fighter leader in the second world war.

Philip Kaplan and Andy Saunders' *Little Friends* is about Don Blakeslee. It's also about James Goodson, Don Gentile, John Godfrey, Francis Gabreski, Bob Johnson, Hub Zemke, and a great gathering of young American fighter pilots. Together with the fighter pilots of the Royal Air Force, they endeavored in 1943 to help the bombers of the Eighth U.S. Army Air Force prove the long-held doctrine that self-defending bomber formations could get to their targets in daylight and return without unnecessary losses.

"As the bomber force struggled back from the target area to fighter-escort range where the rear-cover wing of Thunderbolts or Lightnings would pick them up," co-author Saunders writes, "the sight of these 'little friends' was as welcome as the longed-for first glimpse of the English coastline."

We talked, the colonel and I, about those heady days of long ago, successfully captured in *Little Friends* and still vividly etched in our memories. We talked especially about a mission on August 17, 1943, "Black Thursday," when my Canadian Spitfire wing was detailed to escort the First Bombardment Wing on its flight to attack ball bearing factories in Schweinfurt, Germany.

We found the wing in two big formations, separated by five or six miles. In all there were 230 B-17 Flying Fortresses, and we took up our escort positions a few thousand feet over our "Big Friends," flying with them to the Dutch border. Then, because of our Spitfires' limited range, we had to leave the bombers a few miles east of Antwerp escorted only by a few squadrons of P-47 Thunderbolts that would also soon return to England, leaving the B-17s to fly the remaining two hours to Schweinfurt alone.

When we left them we had not seen an enemy fighter, but back in England, the controller telephoned in the middle of the afternoon to say the bombers were in trouble. Once past Aachen, the armada had been set upon by hundreds of German airplanes. We were to take off immediately.

Over Belgium we saw them coming from afar. It was a sight I shall always remember.

About 10 miles separated the two bomber wings, which had already been harried by flak batteries and fighters for more than four hours. Here, between Liège and Antwerp, the enemy fighter attacks intensified as the depleted bomber formations fought their way home. Well above the bombers, Bf 109s, 110s, and FW 190s left white contrails, which disappeared as the airplanes hurtled down into the warmer air. Heavy flak bursts fouled the sky. Stragglers, miles behind their parent formations, were being picked off. Hub Zemke's Thunderbolts fought valiantly over the rear bomber wing but were about to withdraw. Here and there amid this raging battle, parachutes blossomed. Fortresses fell to the ground and two great columns of black smoke rose from bombers' pyres.

Yet still they came on—these ragged yet majestic formations, unflinching, somehow holding together and closing the gap between us until they were almost beneath us and I was able, at long last, to lead my Canadians into the arena.

But because of our limited range, we were too late. Of the 230 Fortresses that left England, 36, for some reason or another, aborted. Of the remainder, 33 were lost to fighters, one to flak, and two fell to the sea. Many were damaged beyond repair and carried dead and wounded crews. The loss rate, nearly one-fifth of the bomber force, was clearly unacceptable.

What the bombers required was total fighter protection all the way to and from the target, and *Little Friends* recounts that it wasn't until 1944, when the P-51D Mustang entered service, that fighter aircraft could accompany the bombers all the way to Berlin and back.

Beautifully illustrated with historic and contemporary photographs, *Little Friends* ranges well beyond such matters, including chapters on "Those Girls," A-2 jackets, nose art, and the like. But while the browseable book, scrapbook-like and full of pilots' reminiscences, certainly captures the atmosphere of the era, one wishes it could have gone further in places. In particular, it could have said more about how the fighters and bombers of the "Mighty Eighth" fought a gallant battle against the strongest and most lethal fighter defense ever assembled, and how, after months of sustained attacks—assisted by the RAF's night bombers—this round-the-clock offensive tore the heart out of the Nazi regime and smashed that evil empire.

—Air Vice Marshal J.E. "Johnnie" Johnson was the top-scoring British ace in World War II.

Sled Driver: Flying the World's Fastest Jet *by Brian Shul with Sheila Kathleen O'Grady. Mach 1, Inc. (916-893-4000), 1991. 151 pp., color photos, $38 (hardbound).*

Just 152 Air Force aviators have seen Earth from the pilot's seat of an SR-71 Blackbird spyplane. Author Brian Shul is one of them. Better yet, he's one who regularly carried a camera.

Nicknamed "the Sled" by those elite pilots and their backseaters, the SR-71 was still the world's fastest airplane when it retired in 1990, 24 years after its first flight. But *Sled Driver* is not a history of the airplane or a report on its capabilities. Shul says he put the book together both to honor the airplane and to show "one man's view of what it was like to fly the world's fastest jet." He succeeds.

Most of the photos are exceptional: the Sled on the cover, viewed from a refueling tanker, glistens with rain in a shaft of sunlight as it eases up for a several-mile-high fillup; in a side view, a Blackbird's needle nose angles up precisely at the tip of northern California's Mount Lassen, the foothill community of Lake Almanor falling away off the tail; shot from above, a dark-as-a-black-hole Sled guzzles fuel from a KC-135 while puffy clouds and the snow-covered Nevada landscape glide by below.

Even more magnificent are the photos from 75,000 or 80,000 feet, including a view of Southeast Asia in which the blueness and white clouds of Earth contrast with the infinite blackness of space, and one of Earth at sunset, the brightness of day still lingering over the land on the left while on the right, the enveloping blue darkness of night brings out a crescent moon.

At its high points, the writing is vivid, memorable, and entertaining, as when Shul describes turning off

BRIAN SHUL (2)

his cockpit lights at 78,000 feet and discovering that the brightness from the Milky Way and some shooting stars provides all the illumination he needs for a few precious seconds. Or when he describes the sweat and apprehension of spatial disorientation in a thunderstorm, and the exhilaration of breaking out of it.

For an SR-71 admirer, *Sled Driver*'s shortcomings include a lack of a few more photos and, seriously, an unevenness in the writing, a common enough flaw in a co-authored book.

But that's a nitpick. Seeking perfection is looking for what's wrong. Seeking excellence is looking for what's right. We find it in Brian Shul's *Sled Driver.*

—Bob McCafferty is a Fair Oaks, California-based writer and photographer. Formerly a television newsman, he covered military affairs, including the SR-71 home base of Beale Air Force Base.

Flying by the Planets: The Videos, *produced by the Digital Animation Laboratory, Jet Propulsion Laboratory, Pasadena, CA (distributed by Astronomical Society of the Pacific, 415-337-1100), 1991. 35 min., $33.95.*

Six short videos in one, this series of planetary flybys has something of a split personality. The show starts with riveting flights over three regions of the heretofore-veiled planet Venus, the computer-animated sequences created from Magellan radar images (see "Fast Forward on Venus," October/November 1991). For these quick passes, the accompanying printed description is a necessary tour guide. There is no voiceover, since the animation is intended mainly as an interpretive tool for planetary scientists (though a classical soundtrack makes the science a more aesthetic experience). The finale, however, is a tribute to the Voyager program obviously not intended for scientists. While that portion presents some interesting information about Jupiter and Saturn, it is also in spots an unabashed advertisement for the program's sponsor, NASA.

—Linda Shiner is the senior editor of Air & Space/Smithsonian.

Flying Tigers: Claire Chennault and the American Volunteer Group *by Daniel Ford. Smithsonian Institution Press, 1991. 450 pp., maps, b&w photos, $24.95 (hardbound).*

In the early months of World War II in the Pacific, only one small band of Allied fliers successfully challenged the powerful Japanese airmen who ruled the skies. These unique warriors constituted the American Volunteer Group (AVG), a vital part of China's puny air force recruited with promises of adventure and good pay and supplied and supported by the U.S. government. With shark faces painted on the prows of their P-40s and a maverick leader whose hawk-like visage embodied his fierce personality, the Flying Tigers inflicted far more punishment on the Japanese army air force than they received.

The story of the Flying Tigers and their unorthodox commander, Claire Chennault, has been told many times. This latest recounting is probably the most comprehensive and balanced of them all. Daniel Ford's breezy yet detailed narrative describes the Tigers and their leader in realistic terms, portraying both their greatness and their flaws. It is a

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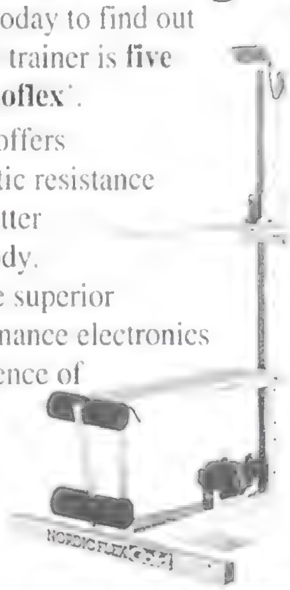

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believable portrait of men who were heroes when the nation badly needed heroes and whose genuine accomplishments have been concealed by a mythology that exaggerates their deeds and character traits.

Flying Tigers examines the difficult role of the AVG in the first Burma campaign, the command and organizational problems Chennault faced, and the airplanes and tactics employed by both sides. Ford, an *Air & Space/Smithsonian* contributor, has conducted some impressive research: in addition to standard sources and personal interviews, he's made extensive use of Japanese materials not seen by other writers. The author is thus able to fully describe Japanese operations and to challenge long-accepted versions of AVG achievements. His selective and abbreviated form of documentation is frustrating, but his conclusions are convincing.

He first takes aim at AVG claims of enemy kills, which Japanese accounts do not support. While Ford's reliance on Japanese loss figures may itself be subject to some modification, it seems evident that the Flying Tigers destroyed far fewer enemy planes than they thought they did. This is not surprising, since air battle claims inevitably tend to err on the plus side, for a variety of good reasons. Nevertheless, Ford clearly indicates that the AVG's kills were disproportionately larger than its meager losses and that these victories forced the surprised enemy to commit more and more aerial

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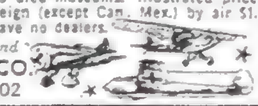
Edward T. Packard—Aviation's Best Friend



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resources to counter the outnumbered Americans.

Ford's second challenge is to the oft-repeated claim that the AVG's main aerial opponent was the famed and previously unexcelled Zero fighter. He demonstrates that what the American pilots thought were Zeros were in fact Type 1s—what the Japanese called the *hayabusa* ("peregrine falcon") and the Allies dubbed "Oscar-II"—a very good army fighter that resembled but did not duplicate the better navy Zero. This by no means denigrates the AVG victories; it simply puts them in proper proportion.

Not surprisingly, the book has stirred up some controversy. Many AVG veterans feel that the author has simply attempted to tear down their reputation. But the book does not give that impression. Ford presents the Flying Tigers in credible perspective, as men who risked their lives against formidable odds, as individuals who differed among themselves in courage, motivation, and performance, and above all as bold combatants whose accomplishments were magnificent.

—Stanley L. Falk is a former chief historian of the Air Force and the author of several books on the war against Japan.

Pilotwings *for Super Nintendo. Nintendo of America (P.O. Box 97043, Redmond, WA 98073). Suggested retail, $49.95.*

It takes more than slick graphics to replicate flight. The only true flying game to be developed for the latest version of the popular Nintendo video "entertainment system," *Pilotwings* confronts the player with lessons of increasing difficulty in hang gliding, skydiving, flying a rocket belt, and piloting a light airplane. Pass through four difficulty levels and you'll find yourself flying a paramilitary mission in an armed helicopter; then the sequence repeats with more difficult tasks and the scene shifted to nighttime. Some of the graphics are dazzling, particularly the night scenes, and the skydiving, hang gliding, and rocket belt portions are fun. But the game's simulation of airplane flight is disappointing. Pitch commands to climb or dive produce changes in altitude, but airspeed and throttle are in effect disconnected. As the Nintendo expert in my house pointed out, "What'd you expect? It's just a video game."

—George C. Larson is the editor of Air & Space/Smithsonian.

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October/November 1988. Mojave Airport, "The International Airplane" poster, L-5 Soci-ety, Lear Fan, nuclear spaceship.

December 1988/January 1989. X-1 engine, mini-space station, Galileo, soaring.

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April/May 1989. Kenya by balloon, Paris Air Show, Energia, ejection seats.

June/July 1989. Special Apollo issue! "Apollo 11" poster, Saturn V, how we got to the moon.

August/September 1989. The C-5, LDEF, parachutes, Japan, Pan Am's Pacific, Kansas space museum.

October/November 1989. Mars propulsion, World War II's black pilots, spacesuits, flight in the funnies, Burnelli.

December 1989/January 1990. Autogiro, Voyager 2, Antarctica, weightless life, Robert McCall.

February/March 1990. The Japanese Zero, Salyut 7, Magellan, around the world with a camera.

April/May 1990. Nuclear cruise missile, mete-orites, Lindbergh, nose art.

June/July 1990. Battle of Britain I, life in Star City, satellite sleuths, solar-power satellites.

August/September 1990. Target drones, Bat-tle of Britain II, spearing a comet, destroying Soviet missiles.

October/November 1990. The Blackbird, go-ing to Mars, Air & Space Museum, Battle of Britain III, space shuttle.

December 1990/January 1991. Sound barrier, Cosmodrome, X-rays, TCAS.

February/March 1991 Blimp, Life on Mars?, Rivets, EW.

April/May 1991. Space shuttle poster, ultra-lights in Egypt, X-31, lifting bodies, kamikazes.

June/July 1991. Mars rovers, Jimmie Angel, P-51, beyond the shuttle.

October/November 1991. World War I fight-ers, asteroids, F-86 pilot, airmail.

December 1991/January 1992. Moonbase, spysats, cocaine wars, Biosphere II, models.

February/March 1992. Pararescue, Admiral Yamamoto, nuclear rockets, Skylab.

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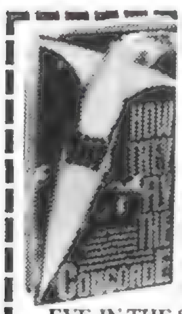

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Credits

Cruising With Regulus. After 46 years in aviation, O.H. Billmann lives the life of a recluse in Simi Valley, California, recalling stories of his professional experience at the drop of a hat (which explains why he is a recluse).

The Jargonauts. If not for his bad knee, Tony Reichhardt probably would have been an astronaut.

The Last Piston Show. Larry Lowe is desperate to race a P-51 before they break the last one.

Further reading: *Reno Air Racing Unlimited,* Nigel Moll, Osprey Publishing, 1983.

Erik's Rocket. When not flying for *Air & Space/Smithsonian,* contributing editor Stephan Wilkinson drives exotic cars for *Condé Nast Traveler* and conducts road tests for *Worth.*

Painting with Numbers. George C. Larson is the editor of *Air & Space/Smithsonian.*

The Shack. A retired air vice marshal from the Royal Air Force, Ron Dick wrote "Meet the Mustang" for the June/July 1991 issue of *Air & Space/Smithsonian.*

Ancient Whisper. Billy Goodman is a science writer living in Brooklyn, New York.

Further reading: *The Red Limit,* Timothy Ferris, William Morrow, 1977.

The First Three Minutes, Steven Weinberg, Basic Books, 1988.

The Air Campaign. Michael Maxtone-Graham, a freelance writer and marketing consultant living in New York City, spent more than 20 years at Warwick Advertising, one of New York's major advertising agencies.

Saving Intelsat VI. Greg Freiherr is a contributing editor of *Air & Space/Smithsonian.*

Birdmen Come to Cleveland. A former editor at *Cleveland Magazine,* Frank Kuznik is now a freelance writer based in Washington, D.C.

Stagecraft and Magic. Steven L. Thompson is a contributing editor of *Air & Space/Smithsonian.*

Calendar

April 4
Airlines International Convention. Buy, sell, and trade commercial aviation memorabilia. Holiday Inn Dallas/Fort Worth North, Irving, TX, (817) 847-2106.

April 11 & 12
Columbus 500 Quincentennial International Air Race. A 500-nautical-mile navigation, time, and fuel race to San Salvador Island. Treasure Cay, Abaco Islands, Bahamas, (813) 251-1115.

April 25 & 26
Kitefest: The Spring Games. River Oaks Park, Kalamazoo County, MI, (616) 383-8778.

May 1–3
Air Racing History Symposium. Holiday Inn–Airport, Cleveland, OH, (216) 255-8100.

May 3
Behind-the-Scenes Tour. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

Pancake Breakfast Fly-In. Bloomington Municipal Airport, Bloomington, IL, (309) 663-7632.

May 7 & 8
Naval Aviation Symposium: "The Battle of Coral Sea: A Historical Perspective" and "The Gulf War: A Critical Analysis." Pensacola Civic Center, Pensacola, FL, (800) 327-5002.

May 9
"First Flight of the Firefly." Naval theme day at Canadian Warplane Heritage Museum. Mount Hope, Ontario, Canada, (416) 679-4183.

May 22–24
Negro Airmen International's Operation Skyhook Fly-In. Flying competitions and barbecue. Moton-Anderson Municipal Airport, Tuskegee, AL, (201) 584-1084.

"The Satellite Sky" Update/29

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Cosmos 2175 1-21-92 PL
- Progress M-11 1-25-92 TT

300 to 630 MILES

- JERS-1 2-11-92 TAN

630 to 1,250 MILES

- Intercosmos 25 12-18-91 PL
- Magion 3 12-18-91 PL

6,200 to 13,700 MILES

- Cosmos 2177-79 1-30-92 TT

21,750 to 22,370 MILES

- DSCS-3 2-10-92 CAC
- Eutelsat II-3 12-7-91 CAC
- Inmarsat 2F3 12-16-91 KOU
- Raduga 28 12-19-91 TT
- Telecom 2A 12-16-91 KOU

DATA: SAUNDERS KRAMER

Deletions

90 to 300 MILES

Cosmos 2060 down 9-1-91

Cosmos 2171 down 1-17-92

DARPA down 1-25-92

Mac 1 down 10-18-91

Progress M-9 down 9-30-91

Progress M-10 down 1-20-92

Inoperative but still in orbit

21,750 to 22,370 MILES

Gorizont 13

Launched but not in orbit

90 to 300 MILES

Cosmos 2174 photo recon	12-17-91	down 1-30-92
STS-42 U.S. research	1-22-92	down 1-30-92

Forecast

In the Wings...

Dream Merchant. Jim Bede has never had a problem inventing airplanes for the homebuilt market, but he's had more than a few problems delivering them. Is his latest invention a true dream machine or just another promise?

Teenysats. Giants in the space industry have discovered that when you're building satellites, less is more.

Lufthansa's Water Wings. With enormous multi-engine flying boats and "floating bases" that catapulted them from the surface of the sea, Lufthansa conquered the south Atlantic, establishing a regular airmail service between Europe and South America by 1934. As late as 1941, the Germans who worked on the project believed it to be the foundation for a heavy transatlantic passenger traffic that would surely follow—as soon as the war was won.

The Planet Hunters. We haven't spotted them yet, but planets like those in our solar system are almost certainly orbiting other stars. With indirect methods and great networks of telescopes, astronomers are drawing closer to finding them.

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Stagecraft and Magic

New Zealand is no longer undiscovered country. Everybody knows that it is beautiful, uncrowded, civilized, and, in places like Christchurch, more English than England. Christchurch is also a popular tourist destination. The capital of the Canterbury province in the South Island, it is a big city with many attractions. Among the most special—and, undeservedly, one of the least known—is the Royal New Zealand Air Force Museum at RNZAF Base Wigram, five miles south of the city center.

The museum is dramatic, compact, and different. Neither its director, Squadron Leader John Barry, Member of the British Empire, nor any of the 12 members of his staff had had previous experience in museum work. They learned on the job how to display the 16 airplanes and artifacts in the museum collection.

"Sort of by happy circumstance," Barry says, "I quite liked designing and drawing and that sort of thing, and I quite enjoyed working on a big project like the museum." An education officer, Barry was asked only months before his scheduled retirement in 1978 whether he'd oversee the whole project. His decision required declining a job with Air New Zealand he was looking forward to, "but doing this [the museum], I was happy as a pig in straw." It took him six years to bring the project from concept to reality. "We're not a rich country," Barry says, "and certainly not a rich service, so we had to do a lot of this ourselves. Everything out there is sort of home-grown."

A Museum Trust was established to finance the construction, drawing upon both government and private funds, and, as the project became known, it rekindled Kiwi enthusiasm for the country's military aviation. "Old Sweats" came out of the woodwork to help as tour guides, restorers, and artifact cataloguers. Seventy docents and 120 volunteers have helped Barry and the staff bring powerfully to life the drama of New Zealand's military heritage.

The restoration workers call themselves the Black Hand Gang and work in the shop inside nearby Hangar 7. The cataloguers label themselves the Geriatric Air Force, complete with emblem: in parody of the RAF/RNZAF crest, the tough-looking eagle on their badge wears spectacles and a bowler hat, and instead of laurel leaves surrounding the shield, their emblem features juniper leaves, symbolic not of victory but of gin. This kind of camaraderie has wrought, Barry says, "its own magic."

As you enter the museum, you're swept into the soaring vault of the atrium, where you're surrounded by a quartet of airplanes—a Blériot XI, de Havilland Tiger Moth, Vampire jet fighter, and McDonnell Douglas A4K Skyhawk—descending in a landing spiral, their control surfaces accurately deployed for the maneuver. Behind the atrium, a breathtaking stained glass window salutes those who fell in World War II.

New Zealanders flew in every World War II combat theater. The air war looms particularly large for this small country, and not simply because of the losses the Kiwis incurred. Most New Zealand aircrew served in Britain's Bomber Command, and the moral questions that are the fallout from Air Chief Marshall Sir Arthur "Bomber" Harris' ruthless nighttime strategic bombing campaign against Germany still concern New Zealanders. An exhibit on that campaign, which lays out the arguments for and against strategic bombing and explains the strategy of the strikes against German cities, is Barry's special gift to the museum visitor, since a frank, balanced discussion of this campaign is rare anywhere else.

Rare too are displays like the museum's exhibit on the Battle of Britain, another important event for New Zealanders. One hundred of them were among "the Few," and the first RAF ace, Flying Officer "Cobber" Kain, was a Kiwi. Barry involves visitors in the conflict by confronting them with a full-size cockpit of a Spitfire mounted in a sky-blue box at waist height. A youthful pilot is rolling the airplane to the right while looking so intently out of the canopy you find yourself glancing over your shoulder to check for Bf 109s. This stunning tableau is typical of the fresh thinking that Barry used to solve the old problem of having to represent dynamic objects and people with static displays. Such exhibits appear around every corner of the cleverly designed Halls of Aviation History, where you are immersed in "the way it was" from 1916 France to 1944 New Guinea.

In the Air New Zealand Aircraft Hall, design technicians, chiefly Dave Nicholson, have used display and lighting techniques to enliven the 12 exhibited aircraft. Nicholson attended the prestigious Parsons School of Design in New York to learn stage lighting, and his talents meshed with Barry's artistic vision to create a discrete visual environment for each airplane. Barry calls it "painting with light." As you enter the hall, you meet the earliest aircraft—a 1936 Hawker Hind—at dawn, then move through the day until you face the specter of a reptilian 1957 English Electric Canberra, bathed in the blue gloom of midnight.

At each display, life-like figures are positioned with the airplanes. A mechanic is frozen in the act of removing the oil filter from the port engine of a 1948 de Havilland Devon, the oil (in reality, a fiberglass "stream") cascading down his hand into a drain pan. Like the other figures throughout the museum, this mechanic wears a face cast from a real person's. The pilot of the Blériot in the atrium strongly favors Barry.

The Wigram museum brings military aviation to life and down to earth, where its valor and daily life and labors can be appreciated. The pace and design of the exhibits set the museum apart from others and create an experience that will impress any aviation-minded visitor.

—Steven L. Thompson

The Royal New Zealand Air Force Museum, RNZAF Base Wigram, Christchurch. Phone: 64-3-343-9532. Open every day but Christmas from 10:00 a.m. to 4:00 p.m. Admission: $3.85.

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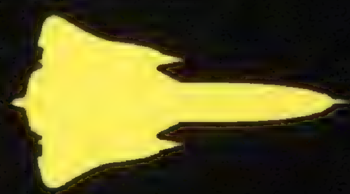
What Makes a Record?

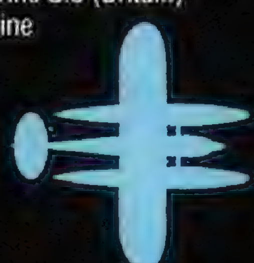
The arbiter of aeronautical records worldwide is the Fédération Aéronautique Internationale, represented in the United States by the National Aeronautic Association. Record-setting flights must be conducted and observed under strict conditions, and some truly record-breaking speeds never became official (record-keeping was also halted during the two world wars). Initially, all speed records were set at an altitude of 100 meters (328 feet) or less, but in the 1950s that regulation was changed for safety reasons. The first official speed record was set in 1906 by Alberto Santos-Dumont, flying at a mere 25.66 mph. The current absolute record is 2,193.17 mph, set by an SR-71 Blackbird on July 28, 1976, at an altitude of 80,000 feet.



The Schneider Trophy

The Schneider competition was launched in 1912 as a speed contest for seaplanes, with the trophy going to the first country to win the race three times in a row. By the time the British won the trophy in 1931, Schneider competitors were the fastest airplanes in the world, with monstrously powerful engines that overcame the drag of seaplane floats.

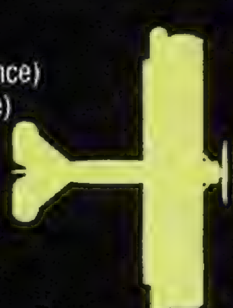
1913: 45.75 mph, Deperdussin (France)
1914: 86.75 mph, Sopwith Tabloid (Britain)
1920: 107.22 mph, Savoia S.12 (Italy)
1921: 117.86 mph, Macchi M.7 (Italy)
1922: 145.7 mph, Supermarine Sea Lion II (Britain)
1923: 177.38 mph, Curtiss CR-3 (U.S.)
1925: 232.57 mph, Curtiss R3C-2 (U.S.)
1926: 246.49 mph, Macchi M.39 (Italy)
1927: 281.65 mph, Supermarine S.5 (Britain)
1929: 328.63 mph,Supermarine S.6 (Britain)
1931: 340.08 mph, Supermarine S.6B (Britain)



World War I

Soon after war broke out in Europe in 1914, the airplane assumed its first substantial role as a weapon. Designers scurried to create models that were faster than the enemy's, developing more powerful engines in an attempt to overcome the drag from the braces and struts of the typical WWI fighter.

Nieuport 17: 107 mph (France)
Spad XIII: 138 mph (France)
Fokker D.VII: 124 mph (Germany)
S.E.5a: 138 mph (Britain)



NACA

Founded in 1915, the National Advisory Committee on Aeronautics was responsible for a number of advances in the quest for speed. The NACA cowling, a design for a streamlined cover that reduced the drag created by large radial engines, alone increased the Lockheed Air Express' top speed by 20 mph. Other research, much of it conducted in the wind tunnels at the Langley Aeronautical Laboratory in Virginia

The Pu

1980

Gossamer Condor
11 mph
8/23/77

1970

1960

1950

Absolute S

Speed	*Date*
25.658 mph	11/12/06
32.789 mph	10/26/07
34.048 mph	5/20/09
43.351 mph	8/23/09
46.179 mph	8/24/09
47.818 mph	8/28/09
48.195 mph	4/23/10
66.181 mph	7/10/10
68.199 mph	10/29/10
69.470 mph	4/12/11
74.415 mph	5/11/11
77.671 mph	6/12/11
80.814 mph	6/16/11
82.727 mph	6/21/11
90.199 mph	1/13/12
100.221 mph	2/22/12
100.945 mph	2/29/12
103.658 mph	3/1/12
104.334 mph	3/2/12
106.116 mph	7/13/12
108.181 mph	9/9/12
111.735 mph	6/17/13
119.240 mph	9/27/13
126.667 mph	9/29/13
171.413 mph	2/7/20
176.136 mph	2/28/20
181.865 mph	10/9/20
184.325 mph	10/10/20
187.983 mph	10/20/20
192.011 mph	11/4/20
194.516 mph	12/12/20
205.223 mph	9/26/21
212.036 mph	9/21/22
223.024 mph	10/18/22
233.014 mph	2/15/23

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peed Records

Airplane	Speed	Date	Airplane
Santos-Dumont 14 *bis*	236.588 mph	3/29/23	Curtiss R-6
Voisin-Farman I	259.478 mph	11/2/23	Curtiss R2C-1
Wright Model A	266.584 mph	11/4/23	Curtiss R2C-1
Curtiss Golden Flyer	278.457 mph	12/11/24	Bernard V.2
Blériot XII	297.817 mph	11/4/27	Macchi M.52
Blériot XII	318.624 mph	3/30/28	Macchi M.52R
Antoinette VII	357.750 mph	9/12/29	Supermarine S.6
Blériot XI	407.494 mph	9/29/31	Supermarine S.6B
Blériot XI *bis*	423.824 mph	4/10/33	Macchi M.C.72
Blériot XI *bis*	440.682 mph	10/23/34	Macchi M.C.72
Nieuport IIN	463.919 mph	3/30/39	Heinkel He 100 V8
Blériot XI	469.221 mph	4/26/39	Me 209 V1
Nieuport IIG	606.256 mph	11/7/45	Gloster Meteor F.4
Nieuport IIG	615.804 mph	9/7/46	Gloster Meteor F.4
Deperdussin	623.608 mph	6/19/47	Lockheed XP-80 Shooting Star
Deperdussin	640.744 mph	8/20/47	Douglas D-558-1 Skystreak
Deperdussin	650.797 mph	8/25/47	Douglas D-558-1 Skystreak
Deperdussin	670.982 mph	9/15/48	North American F-86A-1 Sabre
Deperdussin	698.506 mph	11/19/52	North American F-86D Sabre
Deperdussin	715.747 mph	7/16/53	North American F-86D Sabre
Deperdussin	727.477 mph	9/7/53	Hawker Hunter F Mk 3
Deperdussin	735.542 mph	9/25/53	Supermarine Swift F Mk 4
Deperdussin	752.944 mph	10/3/53	Douglas XF4D-1 Skyray
Nieuport 29V	755.151 mph	10/29/53	North American YF-100A Super Sabre
Spad-Herbemont S.20 *bis4*	822.090 mph	8/20/55	North American YF-100C Super Sabre
Spad-Herbemont 20 *bis6*	1132.126 mph	3/8/56	Fairey Delta 2
Nieuport 29V	1207.635 mph	12/12/57	McDonnell F-101A Voodoo
Nieuport 29V	1404.081 mph	5/16/58	Lockheed YF-104A Starfighter
Spad-Herbemont S.20 *bis6*	1483.834 mph	10/31/59	Mikoyan E-66
Nieuport 29V11	1525.924 mph	2/15/59	Convair F-106A Delta Dart
Nieuport-Delage Sesquiplane	1606.509 mph	11/22/61	McDonnell F4H-1F Phantom II
Nieuport-Delage Sesquiplane	1665.878 mph	7/7/62	Mikoyan E-166
Curtiss R-6	2070.102 mph	5/1/65	Lockheed YF-12A
Nieuport-Delage Sesquiplane	2193.167 mph	7/28/76	Lockheed SR-71A

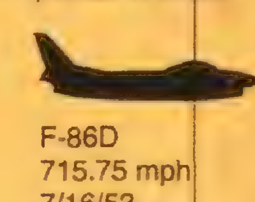
SOURCE: FAI

Boeing Stratocruiser
340 mph
1949

Lockheed Constellation
310 mph
1944

700 mph: F-86D

The F-86 Sabre was the U.S. Air Force's first swept-wing fighter. Fast enough to pass Mach 1 in a shallow dive, the F-86 set three consecutive official speed records in 1948, 1952, and 1953. The last, set by Lieutenant Colonel William F. Barnes, was the first over 700 mph. Barnes was flying an F-86D, an all-weather version of the Sabre that differed so much from earlier models it was once classified as the F-95A. The D was powered by an afterburning General Electric J47-GE-17 engine, which could provide up to 7,650 pounds of thrust.



THE AIRPLANE: From First to Fastest

AIR&SPACE Smithsonian

A supplement to the April/May 1992 issue of *Air&Space/Smithsonian*
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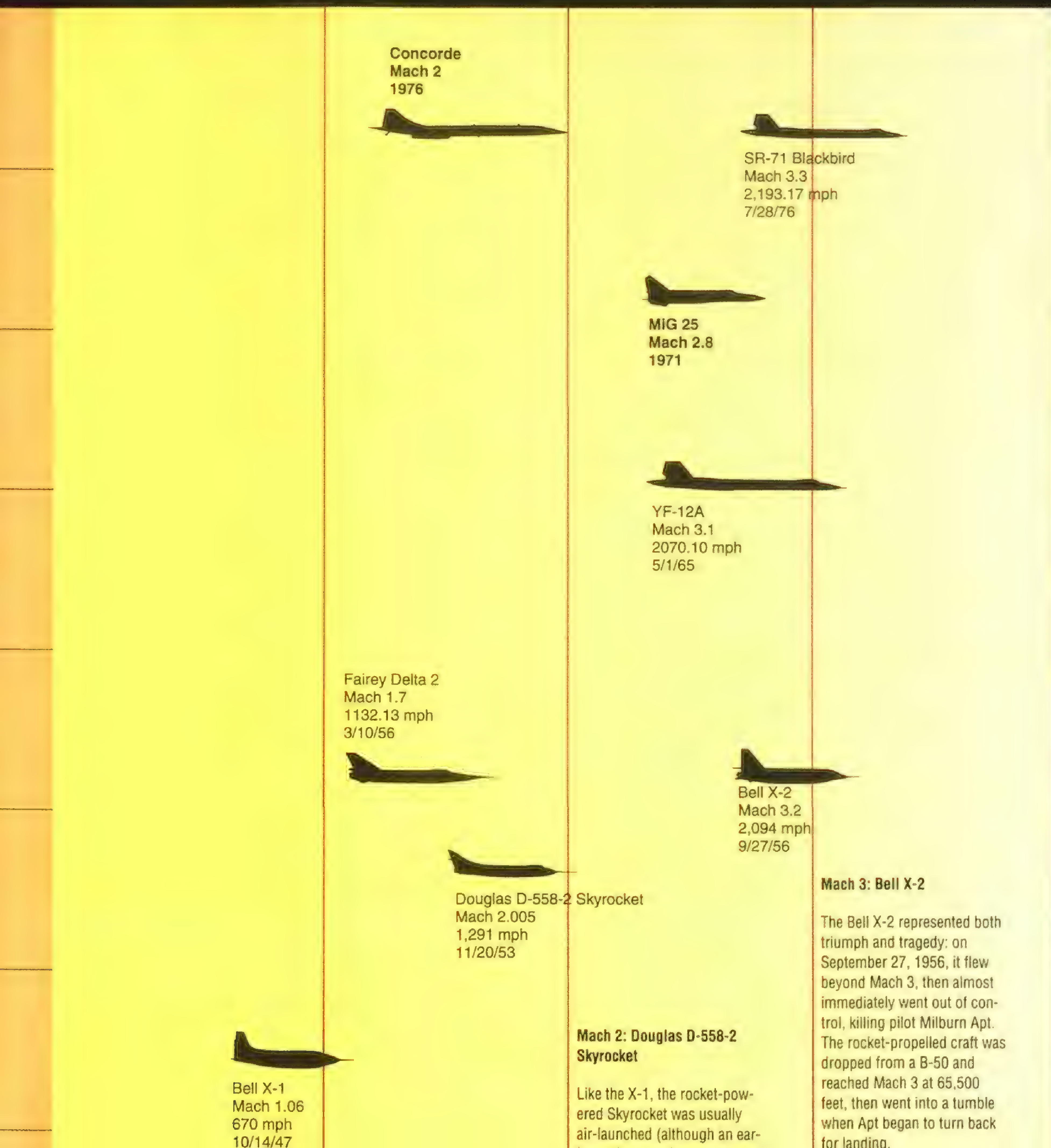


Mach 3: Bell X-2

The Bell X-2 represented both triumph and tragedy: on September 27, 1956, it flew beyond Mach 3, then almost immediately went out of control, killing pilot Milburn Apt. The rocket-propelled craft was dropped from a B-50 and reached Mach 3 at 65,500 feet, then went into a tumble when Apt began to turn back for landing.

Mach 2: Douglas D-558-2 Skyrocket

Like the X-1, the rocket-powered Skyrocket was usually air-launched (although an ear-

led to a better understanding of airfoils and the theory of laminar flow. The NACA also contributed to the design of the Bell X-1, the first aircraft to reach Mach 1, and devoted much effort to studying the problems of high-speed flight. The NACA became NASA in 1958.

World War II

As WWII progressed, ever faster aircraft reached the front lines. Improvements in engines, fuel, and design often made great differences even within a single airplane type: the Spitfire Mk IX, for instance, was a good 40 mph faster than the Mk V. But by this point piston fighters were about to become obsolete, with the Me 262 bringing air combat into the Jet Age.

Mitsubishi A6M2 Zero: 316 mph (Japan)
Hawker Hurricane I: 318 mph (Britain)
Spitfire Mk V: 362 mph (Britain)
Bf 109E: 354 mph (Germany)
P-38F: 414 mph (U.S.)
P-51D: 437 mph (U.S.)
P-47D: 428 mph (U.S.)
F4U-5 Corsair: 462 mph (U.S.)
Me 262A-1a: 540 mph (Germany)

Pistons vs. Jets

The invention of the gas turbine engine made much greater speeds attainable. Reciprocating engines couldn't exceed the speed of sound because their rapidly spinning propeller tips created shock waves that limited their efficiency. By dispensing with propellers, jets eliminated the remaining barrier to Mach 1. In a jet, air enters the engine, where it is compressed and then ignited in a combustor. The burning gases power a turbine that runs the compressor and provide thrust when expelled from the rear of the engine. The world's first jet airplane, the Heinkel 178, flew in 1939 with an engine designed by Hans von Ohain, but jets didn't become operational until the Me 262 entered service in 1944.

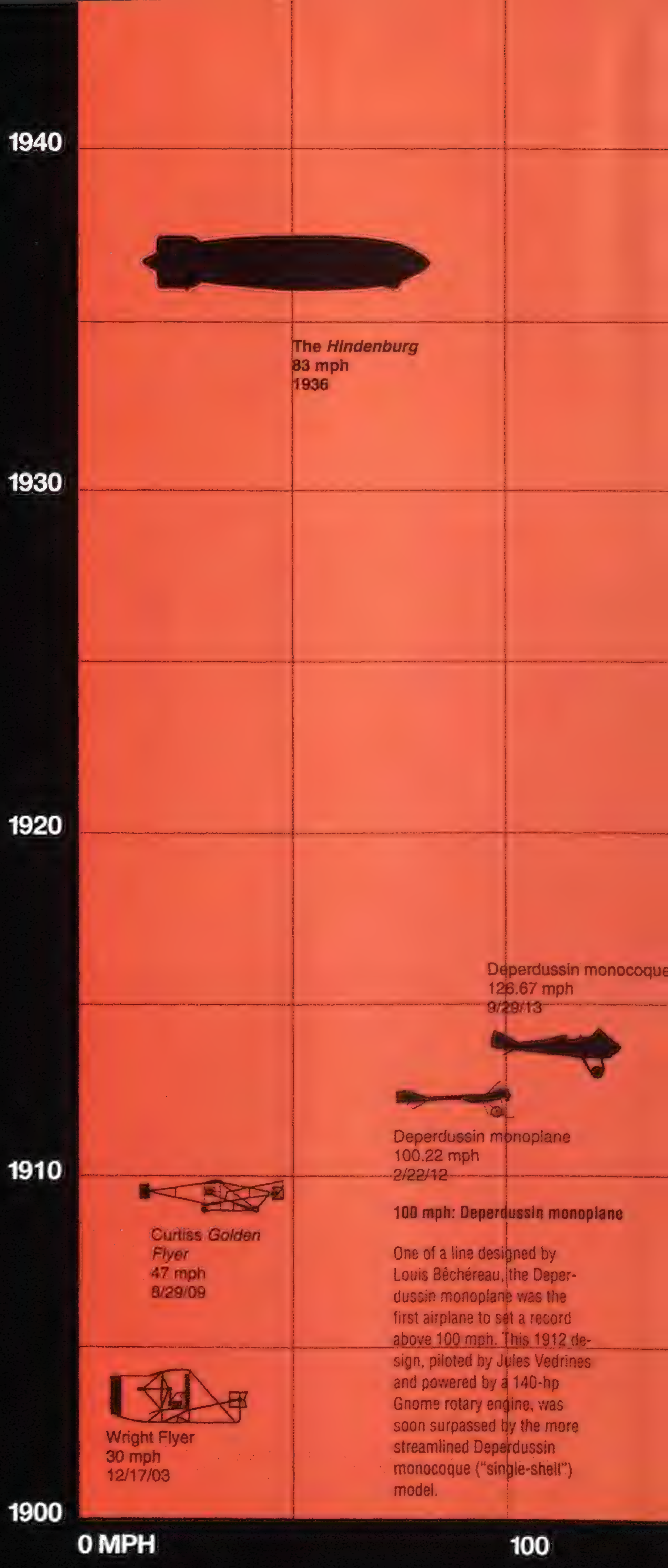
Airliners

In commercial operations, time is money, so speed is of the essence. Airliner speeds took a leap upward in 1952, with the introduction of the de Havilland Comet, the first jet-propelled passenger aircraft. On its debut flight from London to Johannesburg, the Comet cut the 40-hour trip by nearly 17 hours. Most of today's airliners fly around 600 mph, although the Concorde reaches speeds above Mach 2.

Ford Tri-motor: 115 mph
Boeing 247D: 180 mph
Douglas DC-3: 185 mph
Lockheed Constellation: 310 mph
de Havilland Comet: 490 mph
Boeing 707-120: 600 mph
Boeing 747-100: 589 mph
Concorde: Mach 2

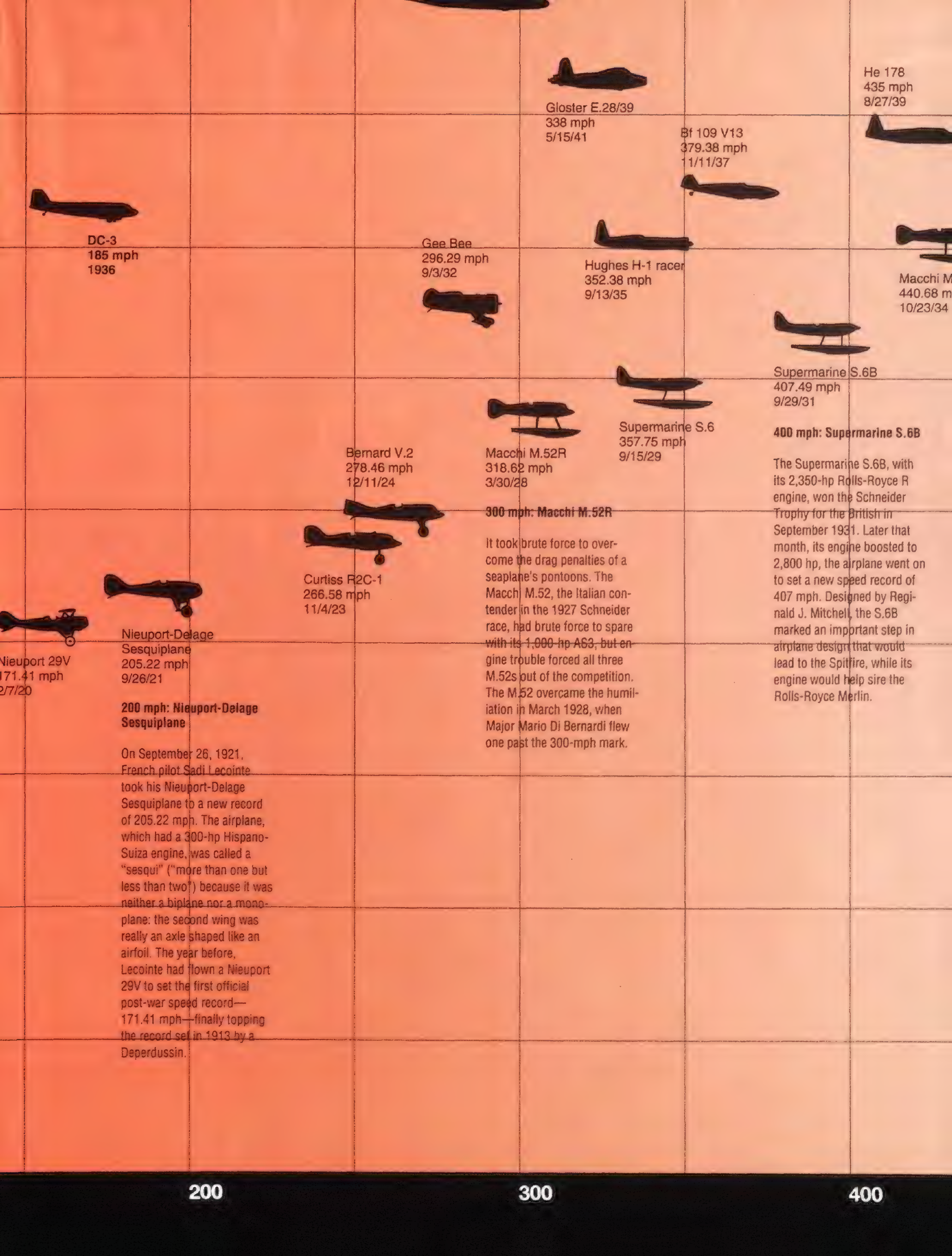
Entries in bold indicate the speed of an airplane type rather than of a specific flight; the year cited is the one in which the airplane entered service. Aircraft not to scale.

Design and Production by Phil Jordan and Julie Schieber



100 mph: Deperdussin monoplane

One of a line designed by Louis Béchéreau, the Deperdussin monoplane was the first airplane to set a record above 100 mph. This 1912 design, piloted by Jules Vedrines and powered by a 140-hp Gnome rotary engine, was soon surpassed by the more streamlined Deperdussin monocoque ("single-shell") model.



200 mph: Nieuport-Delage Sesquiplane

On September 26, 1921, French pilot Sadi Lecointe took his Nieuport-Delage Sesquiplane to a new record of 205.22 mph. The airplane, which had a 300-hp Hispano-Suiza engine, was called a "sesqui" ("more than one but less than two") because it was neither a biplane nor a monoplane: the second wing was really an axle shaped like an airfoil. The year before, Lecointe had flown a Nieuport 29V to set the first official post-war speed record—171.41 mph—finally topping the record set in 1913 by a Deperdussin.

300 mph: Macchi M.52R

It took brute force to overcome the drag penalties of a seaplane's pontoons. The Macchi M.52, the Italian contender in the 1927 Schneider race, had brute force to spare with its 1,000-hp AS3, but engine trouble forced all three M.52s out of the competition. The M.52 overcame the humiliation in March 1928, when Major Mario Di Bernardi flew one past the 300-mph mark.

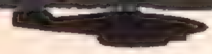
400 mph: Supermarine S.6B

The Supermarine S.6B, with its 2,350-hp Rolls-Royce R engine, won the Schneider Trophy for the British in September 1931. Later that month, its engine boosted to 2,800 hp, the airplane went on to set a new speed record of 407 mph. Designed by Reginald J. Mitchell, the S.6B marked an important step in airplane design that would lead to the Spitfire, while its engine would help sire the Rolls-Royce Merlin.

He 280V-1
485 mph
1941

Bf 209 V1
469.22 mph
4/26/39

2



Me 262
540 mph
1944

500 mph: Me 262

When the German Me 262 became operational in 1944, piston-engine fighters were instantly rendered obsolete. Designed with swept wings that delayed the onset of supersonic shock waves and powered by twin Jumo 004 turbojets that together generated 4,000 pounds of thrust, the Me 262 left anything with propellers in the dust. Though the top speed of a standard Me 262 was only about 540 mph, on July 6, 1944, a modified version reached 624 mph.

Me 163A
623.85 mph
10/2/41

600 mph: Me 163

The rocket-propelled Me 163, powered by a volatile mix of propellants that often exploded on the ground, was as much a threat to its own pilots as it was to enemy aircraft. The Komet was fast, but its limited fuel capacity required dead-stick landings, making it a sitting duck for Allied fighters. The Komet was able to top 600 mph, and in July 1944 an air-launched Me 163 reportedly attained 702 mph.

Me 163
702 mph
7/6/44

The Speed of Sound

The speed of sound varies with temperature. At sea level Mach 1 is around 742 mph. It decreases with altitude until it reaches about 661 mph at 36,000 feet, then remains at that speed in a band of steady temperature up to 60,000 feet. Because of the variation, it is possible for an airplane flying supersonic at high altitude to be slower than a subsonic flight at sea level. The transonic band extends from around Mach .8—when the first supersonic shock waves form on the wing—to Mach 1.2, when the entire wing has gone supersonic.

500 | 600 | 700

◂ SUBSONIC

◂ TRANSONIC ▸

Mach 1: Bell X-1

Although the "sound barrier" of popular myth does not exist, airplanes did face difficulties from the buildup of shock waves as they approached Mach 1. With a fuselage shaped like a .50-caliber bullet, the rocket-propelled Bell X-1 was designed to smash past the barrier, and on October 14, 1947, with Colonel Chuck Yeager at the controls, it did just that. Air-dropped from a B-29, the little airplane reached Mach 1.06 at an altitude of 40,000 feet.

ly version, combining a jet with rockets, could take off under its own power). On November 20, 1953, NACA test pilot Scott Crossfield flew the Skyrocket just past Mach 2, which, at his altitude of 62,000 feet, was about 1,290 mph.

MACH 1

MACH 2

MACH 3

SUPERSONIC ▸

“The 21

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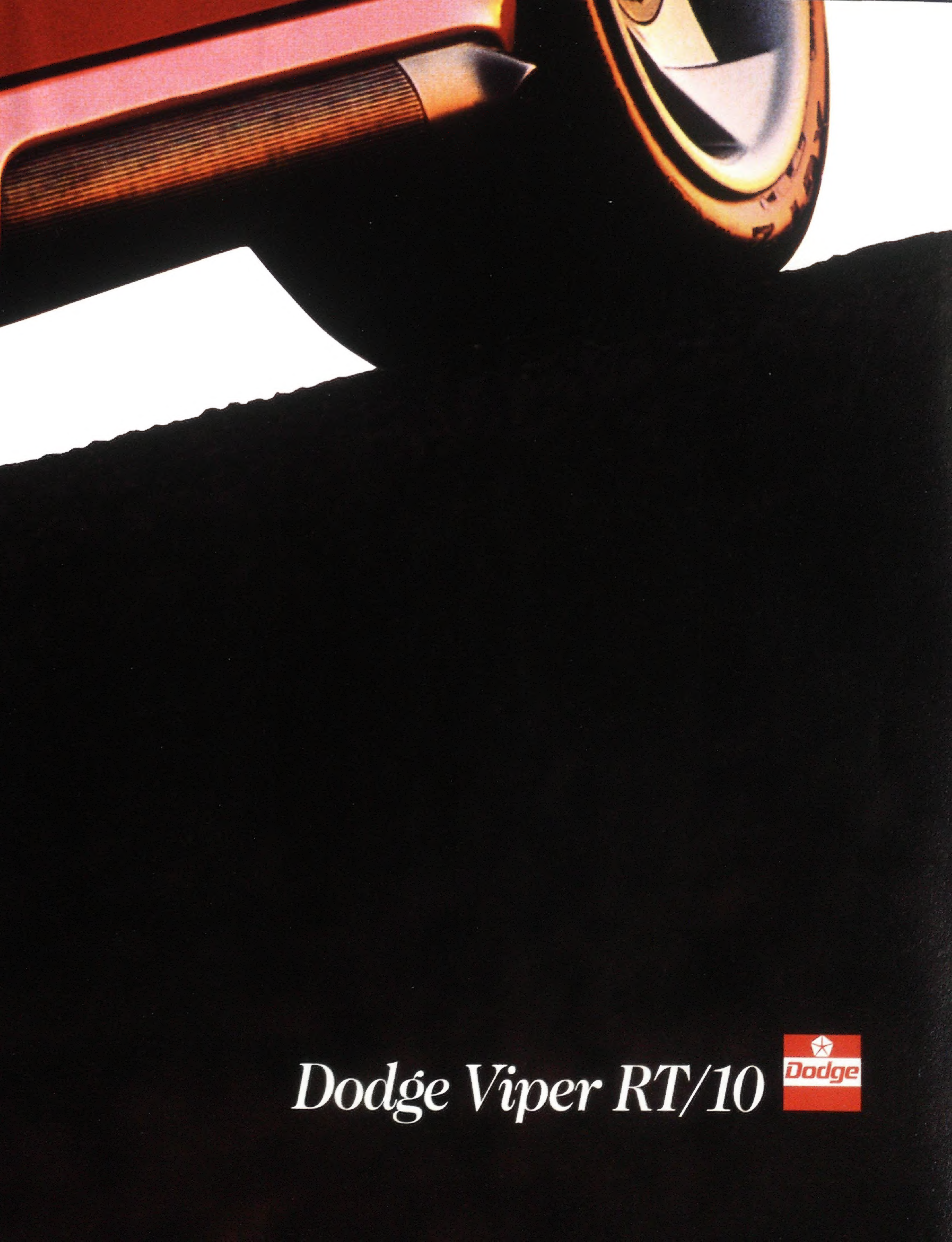
y, and ste

ep on it."


Dodge Viper RT/10
Dodge

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